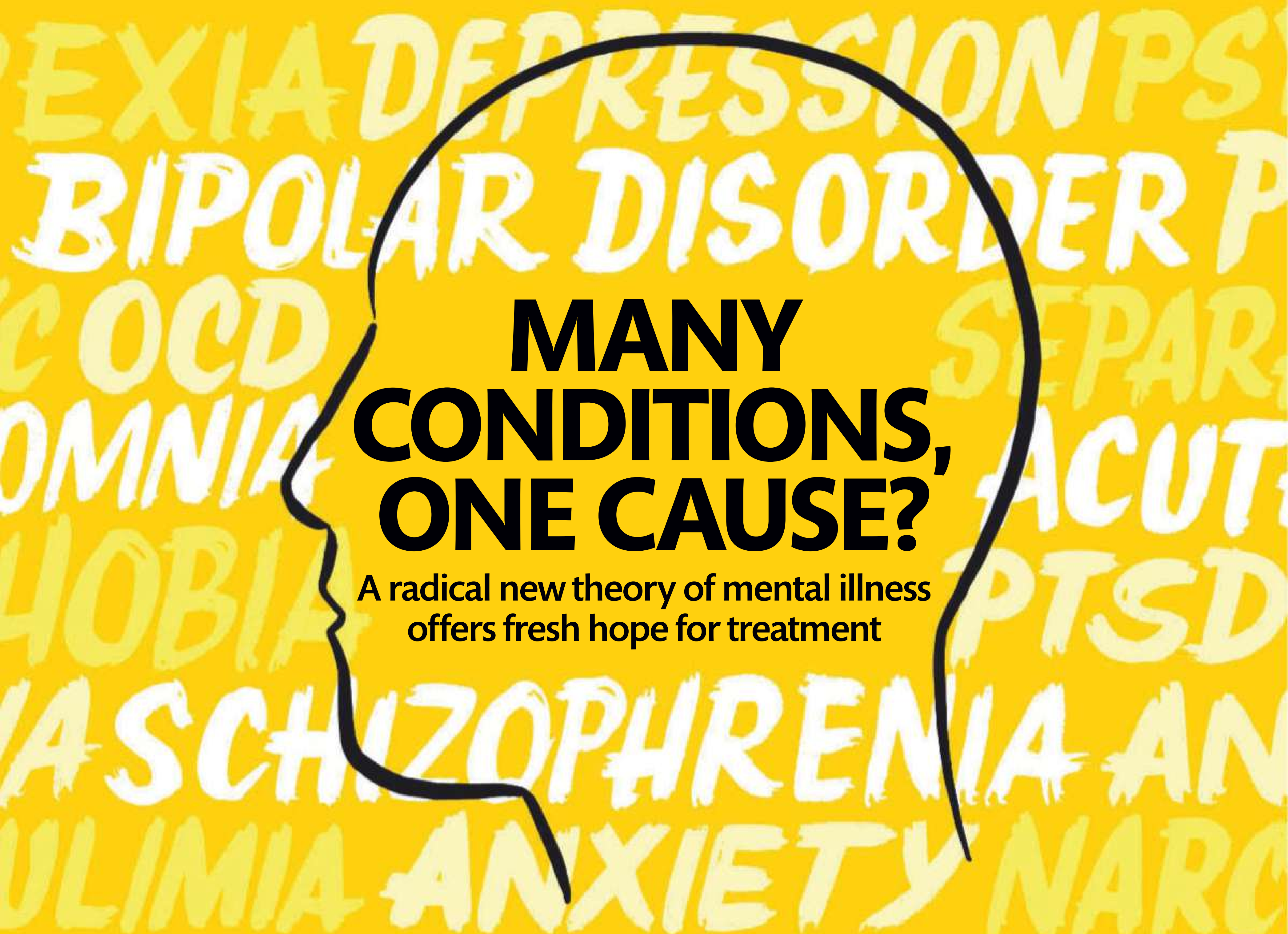
New Scientist

WEEKLY January 25–31, 2020

MOON GARDEN
Inside story of China's lunar farm

OVER THE HORIZON
How Stone Age travelers reached Australia

ASTEROID INCOMING
The people with a plan to prevent an apocalypse



MANY CONDITIONS, ONE CAUSE?

A radical new theory of mental illness offers fresh hope for treatment

THE GREAT NUTRIENT COLLAPSE

Is our food really getting less nutritious?

No3266 US$6.99 CAN$7.99

PLUS GOOP LAB SCIENCE / **A WOLF CUB PLAYS FETCH** / LIVING CONCRETE / **CRISPR CHICKEN** / MYSTERY DRONES

Science and technology news **www.newscientist.com** US jobs in science

Subscription offer

New Scientist can...

...help make you fitter

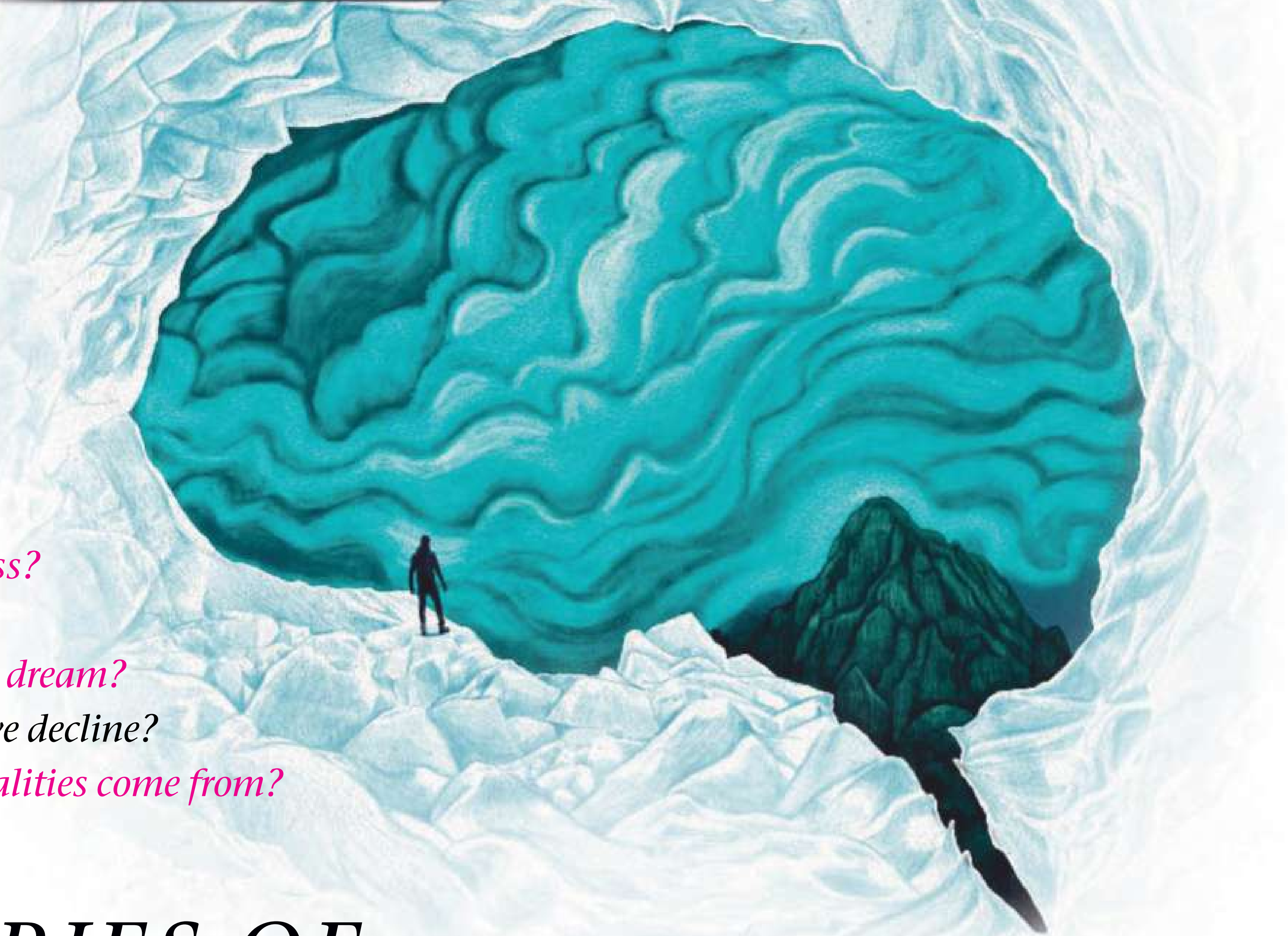
Whether you want to get fitter, live healthier, change your perspective or just spark some winning conversation, *New Scientist* can help you week in week out.

Subscribe and receive a FREE copy of our latest release, *This Book Could Save Your Life* – the ultimate scientific guide to living a longer, healthier life without faddy diets and unproven exercise crazes.

Get started by visiting
newscientist.com/14154
Or call 1 888 822 3242, quoting reference 14154

NewScientist
Know more. *Live better*

Free book available while stocks
last. Only in specific countries



What is consciousness?
What is intelligence?
Why do we sleep and dream?
What causes cognitive decline?
Where do our personalities come from?
and many more

MYSTERIES OF THE HUMAN BRAIN

Explore the intricacies of the most complex object in the known universe with the latest issue of New Scientist: The Collection

Buy your copy from all good magazine retailers or digitally.

ANDROID APP ON Google play

Download on the App Store

This week's issue

On the cover

34 Many conditions, one cause?
A radical new theory of mental illness offers fresh hope for treatment

24 The great nutrient collapse
Is our food really getting less nutritious?

New Scientist

WEEKLY 25 January 2020

MOON GARDEN
Inside story of China's lunar farm

OVER THE HORIZON
How Stone Age travellers reached Australia

ASTEROID INCOMING
The people with a plan to prevent an apocalypse

MANY CONDITIONS, ONE CAUSE?
A radical new theory of mental illness offers fresh hope for treatment

THE GREAT NUTRIENT COLLAPSE
Is our food really getting less nutritious?

PLUS GOOP LAB SCIENCE / A WOLF CUB PLAYS FETCH / LIVING CONCRETE / CRISPR CHICKEN / MYSTERY DRONES

No3266 £4.95 CAN$7.99

15 Moon garden
Inside story of China's lunar farm

38 Over the horizon
How Stone Age travellers reached Australia

42 Asteroid incoming
The people with a plan to prevent an apocalypse

New Scientist events

Instant Expert: Human Evolution
Explore the discoveries that are rewriting the story of our origins
Join six expert speakers in London on 29 February for a one-day masterclass. Find out more at newscientist.com/events

23 Goop Lab science 18 A wolf club plays fetch
18 Living concrete 9 CRISPR chicken 14 Mystery drones

Vol 245 No 3266
Cover image: Angela Southern

News

8 Our ghost lineage
Long-lost branch of human history revealed

9 Restoring fertility
Cell injections found to rejuvenate ovaries

20 Allergy food fight
Are baby-weaning guidelines the reason food allergies have become more common?

Views

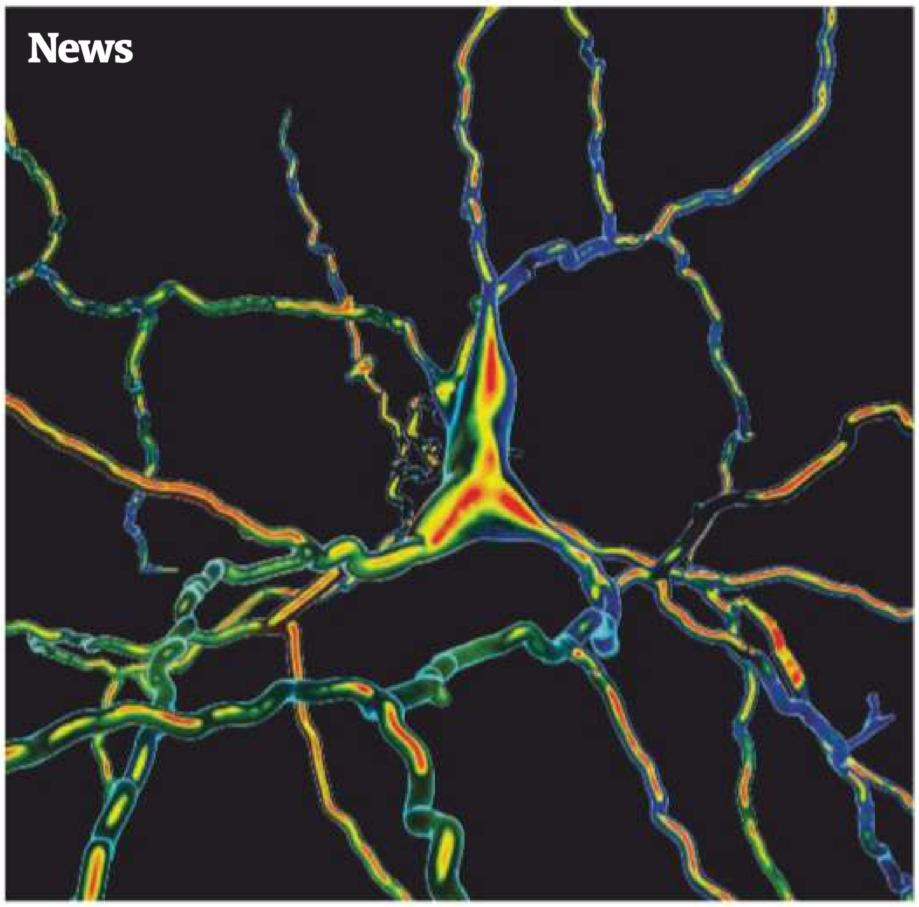
23 Comment
Bad science in *The Goop Lab* is easy to fall for, says Clare Wilson

24 The columnist
James Wong on claims that food is less nutritious

26 Letters
Pedestrian-friendly cities need room to play too

28 Aperture
Making an artificial glacier in the Himalayas

30 Culture
Why civil rights go hand in hand with access to IT



KATERYNA KON/SCIENCE PHOTO LIBRARY

11 Dopamine hit An AI learning technique is used by our brains too

34 Features

> "For millennia, we've put psychiatric conditions in separate corners, but maybe that's not how it works"

Features

34 Many conditions, one cause?
The surprising connections making us rethink mental health

38 Over the horizon
The epic Stone Age journey to discover Australia

42 Asteroid incoming
A step-by-step guide to how we would save the planet

The back pages

51 Science of cooking
Make tofu for Chinese New Year

52 Puzzles
A black hole cryptic crossword and a land problem

53 Feedback
Spoon-bending and military dolphins: the week in weird

54 *Almost* the last word
Red sky at night and shampoo vs shower gel: readers reply

56 The Q&A
Brendan Walker on designing thrilling experiences

NewScientist

SECOND EDITION OF
BEING HUMAN

BEING
HUMAN

Take a step back from the everyday chores of being human to tackle the big – and small – questions about our nature, behaviour and existence.

Buy your copy from all good magazine retailers or digitally.
Find out more at **newscientist.com/TheCollection**

ANDROID APP ON Google play

Download on the App Store

Common cause

Genetic analyses point to a new way to think about mental health

THIS year alone, one in four people in the UK will experience a mental health condition. That includes everything from depression and anxiety to schizophrenia and phobias. Meanwhile, surveys suggest that our ability to cope with these issues is getting worse.

The personal costs of all this are huge, as are those to society. And our treatment options are limited: some conditions defy treatment, even proven interventions don't always work and many people get no treatment at all. At the same time, those who experience one condition often experience others.

But now new research into the possible causes of mental illness offers fresh hope for a better way forward (see page 34). Hundreds of distinct psychiatric conditions are currently recognised by mental health professionals, but new DNA sequencing techniques reveal that many share an underlying genetic link. Of course, experiences and environment also play a big role. But this common factor – or "p factor" as researchers call it – may help explain why some people seem more prone to mental health issues across their lifetimes. As evidence for this link grows – and the medical establishment starts to take it seriously – this understanding brings new opportunities for treatment.

> **"This new understanding suggests putting less emphasis on labelling conditions and more on treating symptoms"**

That may start with putting less emphasis on labelling conditions and more on treating symptoms. We already know that some interventions can cross diagnostic boundaries: several drugs are effective for a number of conditions, for instance, as are talking therapies.

Some mental health professionals already use a one-size-fits-all version of cognitive behavioural therapy, called the common elements treatment approach, for people with many different conditions. If this new thinking about mental health is right, these kinds of general treatments may actually be the most useful first interventions for most people and conditions. What's more, this strategy could also increase access to treatment where resources are limited.

Perhaps then, in future, we could devote less time and money to searching for separate treatments and more time to truly helping people. ▮

NewScientist

PUBLISHING & COMMERCIAL

Display advertising
Tel +44 (0)20 7611 1291 **Email** displayads@newscientist.com
Commercial director Chris Martin
Display sales manager Justin Viljoen
Lynne Garcia, Bethany Stuart, Henry Vowden,
(ANZ) Richard Holliman
Recruitment advertising
Tel +44 (0)20 7611 1204 **Email** nssales@newscientist.com
Recruitment sales manager Viren Vadgama
Nicola Cubeddu, (US) Jeanne Shapiro
New Scientist Live
Tel +44 (0)20 7611 1245 **Email** live@newscientist.com
Events director Adrian Newton
Creative director Valerie Jamieson
Event manager Henry Gomm
Sales director Jacqui McCarron
Exhibition sales manager Rosie Bolam
Marketing manager Katie Cappella
Events team support manager Rose Garton
Marketing executive Jessica Lazenby-Murphy
Marketing
Head of campaign marketing James Nicholson
Digital marketing manager Poppy Lepora
Head of customer experience Emma Robinson
Email/CRM manager Rose Broomes
Head of data analytics Tom Tiner
Web development
Maria Moreno Garrido, Tom McQuillan, Amardeep Sian

© 2020 New Scientist Ltd, England.

New Scientist ISSN 0262 4079 is published weekly except for the last week in December by New Scientist Ltd, England. New Scientist (Online) ISSN 2059 5387. New Scientist Limited, 387 Park Avenue South, New York, NY 10016

Periodicals postage paid at New York, NY and other mailing offices

Postmaster: Send address changes to New Scientist, PO Box 3806, Chesterfield, MO 63006-9953, USA.

Registered at the Post Office as a newspaper and printed in USA by Fry Communications Inc, Mechanicsburg, PA 17055

MANAGEMENT

Chief executive Nina Wright
Finance director Jenni Prince
Chief technology officer Chris Corderoy
Marketing director Jo Adams
Human resources Shirley Spencer
HR coordinator Serena Robinson
Facilities manager Ricci Welch
Executive assistant Lorraine Lodge
Receptionist Alice Catling

Non-exec chair Bernard Gray
Senior non-exec director Louise Rogers

CONTACT US

newscientist.com/contact
General & media enquiries
US **Tel** +1 617 283 3213
PO Box 80247, Portland, OR 97280
UK **Tel** +44 (0)20 7611 1200
25 Bedford Street, London WC2E 9ES
Australia 418A Elizabeth St, Surry Hills, NSW 2010
US Newsstand
Tel +1 973 909 5819
Distributed by Time Inc. Retail, a division of Meredith Corporation, 6 Upper Pond Road, Parsippany, NJ 07054
Syndication
Tribune Content Agency
Tel 1-800-346-8798 **Email** tca-articlesales@tribpub.com
Subscriptions
newscientist.com/subscribe
Tel 1 888 822 3242
Email newscientist.na.subs@quadrantsubs.com
Post New Scientist, PO Box 3806, Chesterfield MO 63006-9953

EDITORIAL

Editor Emily Wilson
Executive editor Richard Webb
Creative director Craig Mackie
News
News editor Penny Sarchet
Editors Lilian Anekwe, Jacob Aron, Chelsea Whyte
Reporters (UK) Jessica Hamzelou, Michael Le Page,
Donna Lu, Adam Vaughan, Clare Wilson
(US) Leah Crane
(Aus) Alice Klein
Interns Gege Li, Layal Liverpool, Jason Arunn Murugesu
Digital
Digital editor Conrad Quilty-Harper
Podcast editor Rowan Hooper
Web team Anne Marie Conlon,
David Stock, Sam Wong
Features
Head of features Catherine de Lange
and Tiffany O'Callaghan
Editors Gilead Amit, Julia Brown, Daniel Cossins,
Kate Douglas, Alison George
Feature writer Graham Lawton
Culture and Community
Comment and culture editor Timothy Revell
Editors Liz Else, Mike Holderness, Simon Ings
Education editor Joshua Howgego
Subeditors
Chief subeditor Eleanor Parsons
Bethan Ackerley, Tom Campbell, Chris Simms, Jon White
Design
Art editor Kathryn Brazier
Joe Hetzel, Dave Johnston, Ryan Wills
Picture desk
Picture editor Susan Banton
Production
Production manager Alan Blagrove
Robin Burton, Melanie Green

Where did we come from?
How did it all begin?

And where does belly-button fluff come from?
Find the answers in our latest book. On sale now.

JM

Introduction by **Professor Stephen Hawking**

New Scientist

CRISPR poultry
Gene editing protects chickens from common virus **p9**

Sustainable food
We need to change how we farm worldwide **p10**

Brunch is bad
Eating late at the weekend is linked to weight gain **p12**

Mystery drones
Are sightings of unidentified swarms in the US real? **p14**

Asgard archaea
Getting to know our simple, single-celled relative **p16**

STR/GETTY

Some of those infected have been treated at Jinyintan hospital in Wuhan

Wuhan virus spreads

We now know the virus responsible for deaths and infections in China can pass between people, reports **Jessica Hamzelou**

AT LEAST six people are reported to have died after being infected with a new virus spreading in China. The coronavirus can spread person to person, the country's health ministry has confirmed.

The two latest reported deaths in China were that of a 66-year-old man and a 48-year-old woman in Wuhan, according to the Wuhan Municipal Health Commission. Sixty new cases were reported in the region on 20 January. Among them are 15 healthcare workers, according to news site China Daily.

Zhong Nanshan, head of the Chinese national health commission team that is investigating the outbreak, has now confirmed that two cases of infection had been caused by human-to-human transmission.

"It is now clear that there is person-to-person transmission, which is a worrying development," says Rosalind Eggo at the London School of Hygiene and Tropical Medicine. "We've got to wait and see how sustained that transmission is."

The Wuhan Municipal Health Commission said that 258 people have been infected in that part of China. At the time, 227 of them were still being treated in hospital.

Cases have also been confirmed elsewhere in China, in Guangdong province, Beijing and Shanghai. Beyond China, a handful of cases have been confirmed in Japan, Thailand, South Korea and Taiwan, all either people from Wuhan or those who had visited the city.

When *New Scientist* went to press, the director-general of the World Health Organization was due to hold an emergency meeting on Wednesday to decide whether the outbreak constitutes a public health emergency of international concern, and to issue recommendations on how to manage it.

"This is a critical point in the outbreak," says Eggo. "Although there are more signs that this outbreak is serious, we still don't know exactly what is going on." Over the next week or so, we will find out how easily the virus can be passed from one person to another and whether the infection is spreading in countries outside China, she says.

In total, nearly 300 cases of infection with the virus have been confirmed. But a report released on 17 January based on infectious disease modelling suggests there may be hundreds more cases in the city of Wuhan that haven't been diagnosed.

Given the number of cases reported outside China, it is possible that more than 1700 people have been infected in the city, suggest Natsuko Imai and her colleagues at Imperial College London.

The team reached that estimate based on the number of international travellers flying out of Wuhan, the population of Wuhan international airport's catchment area and the fact that, on average, it appears to take around 10 days for an infected person to start showing symptoms.

In Australia and several countries in Asia, air passengers arriving from China will be screened on arrival to see if they have a raised body temperature or other symptoms. The US Centers for Disease Control announced last week that it will begin screening travellers from Wuhan at airports in San Francisco, New York and Los Angeles.

We know the pathogen that is spreading in China is from the same family as the SARS and MERS viruses, which can also cause acute respiratory illness and which led to fears that they could become global threats. ▮

More on infectious conditions online
For the latest on pathogenic organisms, visit
newscientist.com/infectious-diseases

Discover the story of human evolution
Come to a masterclass in London on 29 February
newscientist.com/science-events

Ancient humans

Our ghost lineage

A pioneering analysis of ancient African DNA has discovered an unknown branch of our species' family tree, reports **Alison George**

DNA evidence from four ancient skeletons uncovered in western Cameroon has revealed a long-lost mystery branch of early modern humans, suggesting we may need to rethink our species' family tree.

The skeletons all belonged to children who were buried at a rock shelter at a site called Shum Laka. Two of the skeletons are 8000 years old, and the other two are about 3000 years old. Despite living 5000 years apart, genetic analysis by David Reich at Harvard Medical School and his colleagues suggests that they were from the same population of modern humans.

The team was interested in the skeletons because linguistic studies have suggested that the Bantu languages, which are spoken today by around 30 per cent of people in Africa, originated in this region. However, the genetic signature of these remains look nothing like those of the people known to have spread the Bantu languages across the continent.

By comparing the Shum Laka people's genetic signatures with those in databanks of modern African populations, the team found that a third of the children's DNA was similar to that of Central African hunter-gatherers – but the rest is a mystery (*Nature*, DOI: 10.1038/s41586-020-1929-1). "Two-thirds of their ancestry is related to a modern human lineage that we've never seen before. That's exciting," says Reich.

Previous genetic studies have suggested that the very earliest modern humans split into three branches between 250,000 and 200,000 years ago. These were the southern African hunter-gatherers, the Central African hunter-gatherers and a lineage that leads to most other modern humans including most East and West Africans. But the bulk of the Shum Laka skeletons' genetic make-up doesn't match any of these three groups. This suggests there was a fourth branch early on in our species' history.

"What we think is that most of the Shum Laka ancestry is from a lineage that hadn't been identified before, but was present in very high proportions as recently as 3000 years ago at the site and presumably other sites too," says Reich. He thinks this ghost lineage was later displaced by the Bantu expansion and other population changes.

> "A much more diverse landscape of very different humans were living a few thousand years ago"

The evidence for the three early branches of our species has come mainly from looking at the genomes of modern-day Africans, which may be why we hadn't detected this fourth group, as this ancestry has been mostly lost from today's populations.

"It's exciting to get ancient DNA from Africa, especially central Africa where ancient DNA doesn't preserve well because it's a tropical region," says Sarah Tishkoff at the University of Pennsylvania.

One of the skeletons, a 15-year-old boy from 8000 years ago, was found to have a variant of a rare genetic signature on his Y chromosome, known as A00. First discovered in 2013, this signature showed that our species' last shared male ancestor lived 200,000 to 300,000 years ago.

The analysis also found that the Shum Laka genomes contain traces from an archaic hominin species that no longer exists. Many people around the world carry DNA from extinct hominins like Neanderthals or Denisovans. But less is known about archaic hominins that contributed to the genomes of some African populations.

About 2 per cent of the DNA of the Shum Laka people seems to have come from an unknown extinct species that one of their ancestors interbred with.

Excavating the 8000-year-old remains of two boys in Cameroon

ISABELLE RIBOT

A great diversity

There are also signs of much interbreeding with other human populations. All this points to a time in our history when Africa was inhabited by a much greater diversity of humans. "If you go back in time to a few thousand years ago, what you see is a much more diverse landscape of very different groups of humans living in the region," says Reich.

Tishkoff says the hypothesis that the Shum Laka people were different from any modern populations is interesting, but isn't conclusive yet. "Additional samples and analysis will be needed to be able to reconstruct the complex demographic history of Africa," she says.

Joshua Akey at Princeton University says the study has implications for our understanding of the origin of humans. "Perhaps modern humans did not originate in any particular location in Africa, but evolved across a broad swathe of the African continent," he says.

Ultimately, it may have been genetic "admixture" – mixed up DNA that is the result of many populations interbreeding – that predominantly contributed to the make-up of modern humans, says Akey.

Further insights are expected later this year when Tishkoff and her colleagues publish the largest ever analysis of genomes from across contemporary Africa. ▮

Health

Cell injections may restore fertility lost through cancer treatment

Jessica Hamzelou

IT MAY be possible to rejuvenate ovaries after chemotherapy without the need for surgery, after the fertility of female mice was successfully restored following injections of donor cells.

The approach involves injecting either stored or donated follicles – the cells in ovaries that contain and eventually release egg cells – into the ovaries. The technique is "able to rejuvenate the potential of the ovary using donated follicles" and could "prolong the fertility of women", says Michael Dahan at McGill University in Montreal, Canada, who wasn't involved in the work.

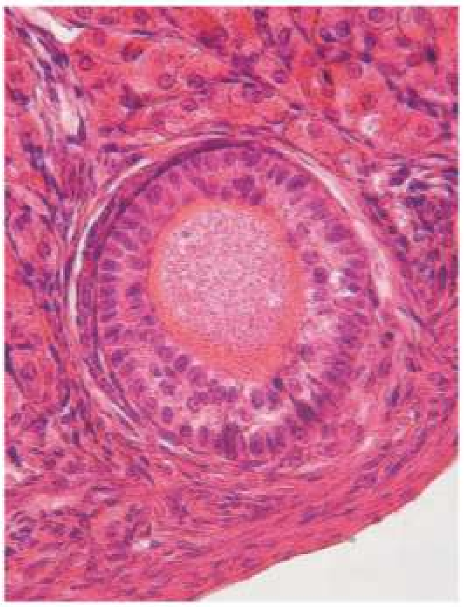
Some cancer treatments can affect the supply of eggs, and may make it more difficult to conceive after treatment. People undergoing these treatments may have pieces of their ovary removed and frozen beforehand, in order to preserve their fertility. These tissues can then be surgically reimplanted if someone wants to get pregnant. Over 130 babies have been born following this type of procedure.

But the approach is still new, and some doctors worry about the risk of reimplanting cancer cells. "If a woman has ovarian cancer or leukaemia, you wouldn't want to put that tissue back in," says Kyle Orwig at the University of Pittsburgh in Pennsylvania. "The worst thing you can do is give cancer back to a survivor."

Orwig and his colleagues have developed a different approach. Instead of implanting ovary tissue, the team only implants the follicles. This should avoid implanting any cancer cells, says Orwig.

To test the approach, the team gave four female mice varying doses of two chemotherapy drugs that Orwig says cause infertility in humans. The team then collected follicles from donor mice who hadn't undergone chemotherapy and injected them into the ovaries of the female mice that had.

Two of the four mice later gave birth to pups, some of which had features of the donor, rather than those of their parents. This led the team to be sure that it had been the injection of follicles that had resulted in pups with the same features (bioRxiv, doi.org/djqq).


GARRY DELONG/GETTY

Ovarian follicles are structures that contain and release eggs

Orwig thinks the approach could also be used to inject people with their own stored follicles. "You wouldn't need a surgical procedure," he says. Instead a procedure similar to one already used to collect eggs for IVF, where a needle is used to access the ovaries via the vagina, could be used. "Instead of taking eggs out, you could inject follicles," he says.

The follicles could also be taken from donors, says Dahan, and they might be easier to obtain than donor eggs. And while people who receive donated organs need to take drugs to suppress the immune system, those who receive follicles might not need to as "there is a minimal risk of rejection", says Dahan.

In theory, the approach could be used in humans straight away, says Orwig. Regulatory bodies allow a person's own cells to be reinjected into them if they have only been exposed to "minimal manipulation". But Orwig says his next step will be to trial it in monkeys first.

There are still questions that need to be answered. We don't know how infertile the mice were before the treatment, and whether the technique would work if the mice had no ovaries, for example.

"It is a unique approach, and the concept is interesting," says Monica Laronda at Northwestern University in Chicago. "But there is definitely more [work] that I would like to see." ▮

Gene editing

CRISPR-edited chickens made resistant to virus

CRISPR genome editing has been used to make chickens resistant to a common virus. The approach could boost egg and meat production worldwide while improving welfare.

The altered chickens showed no signs of disease even when exposed to high doses of the avian leukosis virus (ALV). The virus is a problem for poultry farmers around the world, says Jiri Hejnar at the Czech Academy of Sciences.

Infected birds become ill, emaciated and depressed, and often develop tumours. The virus gets into cells by binding to a protein known as chNHE-1. Hejnar's team has previously shown that deleting three DNA letters from the *chNHE-1* gene that makes this protein prevents ALV from infecting chicken cells.

The challenge was to make this change in entire animals rather than just in a few cells. No strains of chickens naturally have this mutation, so it can't be done by breeding alone.

"A company is in discussion with poultry producers about using the change in commercial breeds"

In 2017, Hejnar developed a suitable method: using altered germ cells to restore semen production in sterilised cockerels. His team then went on to create a cockerel with sperm that have the precise deletion in the *chNHE-1* gene.

By crossing its offspring, they have produced a flock of white leghorn chickens that have this deletion in both copies of the gene (*PNAS*, DOI: 10.1073/pnas.1913827117).

A company called Biopharm is now in discussion with poultry producers in Vietnam and China about introducing this change into commercial breeds. "It's quite simple to do," says Hejnar.

Hejnar also plans to use CRISPR to make chickens resistant to other viruses, such as bird flu. This could make us all safer: bird flu viruses sometimes kill people and there are fears that a mutant strain could cause a deadly global pandemic.

However, it remains to be seen whether consumers will want to eat CRISPR chickens. ▮
Michael Le Page

Environment

Deforestation for rubber

Sustainable plantation criticised for destroying elephant habitat

Adam Vaughan

TYRE giant Michelin and green group WWF have been criticised by researchers over a rubber plantation in Indonesia that was billed as protecting the environment, but which villagers say has caused deforestation, destroyed elephant habitat and resulted in land grabs.

In 2015, Michelin began work on the 66,000 hectare plantation on the island of Sumatra, partnering with WWF as an adviser, to source rubber from an area that Michelin had said had been ravaged by fires and logging. The French company, one of the world's biggest buyers of rubber, promised the plantation would be "deforestation-free", "protect flora and fauna" by creating a buffer zone for wildlife and generate 16,000 jobs.

But a visit by German researchers to the nearby village of Muara Sekalo in the province of Jambi has unearthed a very different account of the project's impact. Farmers from the village, and women working for one of the plantation's partners, told the team that forests had been cleared to establish the rubber trees.

F OTTEN/UNIVERSITY OF GÖTTINGEN

A view from the Muara Sekalo village in Jambi, Indonesia

Villagers also reported that the plantation had destroyed the habitat of elephants, leading more of the animals to approach the village and become more aggressive, destroying farmers' plantations (*Journal of Land Use Science*, doi.org/djt4). Several farmers were said to have eventually abandoned their plots as a result.

Some of the villagers reported losing land to the plantation, often because they only held rights through custom, not official deeds recognised by government ministries. One village elder said of land with trees his ancestors had grown: "I feel like it is not fair to give the land to the company, but then we don't have any proof of the ownership but the trees."

"The main point is really the mismatch between the framing of sustainable development on the one side and what's happening on the ground on the other," says Fenna Otten at the University of Gottingen, Germany, who visited the village at the end of 2017.

She says the project wasn't entirely negative. Villagers reported that the plantation had created jobs, and one person was excited by the prospect of being trained in rubber tapping. Some of the women working for the plantation were pleased to be paid cash in hand. Others said the economic impact was mixed. One villager said: "The village economy did not change significantly, sometimes the situation is better, sometimes it is worse."

In a statement, Michelin said the project was "very important to Michelin and to all its stakeholders" and it regretted the researchers hadn't contacted the company.

WWF said it was an adviser on the project, but not involved in running it. "Although we regret the authors of the report haven't contacted us to verify the study, we shall discuss the findings with all those involved and call for them to urgently address any concerns raised by the local communities," a spokesperson says. ▮

Agriculture

How to feed Earth's booming population

OUR current food system can feed only 3.4 billion people without transgressing key planetary limits, according to an analysis of the global farming system.

However, reorganising what is farmed where – along with some changes in diets – would enable us to feed 10 billion people sustainably, suggests the study. In 2009, researchers identified nine so-called planetary boundaries: limits that we shouldn't exceed if we want to maintain Earth's life-support systems.

Dieter Gerten at the Potsdam Institute for Climate Impact Research in Germany and his colleagues looked at the four boundaries that are relevant to farming: not using too much nitrogen; not taking too much fresh water from rivers; not cutting down too much forest; and maintaining biodiversity.

The team's conclusion is that half of food production today violates these limits. However, this analysis is also the first to provide insights into where these limits are being transgressed. By changing what is farmed where, the team says it would be possible to feed 10 billion people within the four limits.

This would involve rewilding farms in areas where more than 5 per cent of species are threatened, for instance, and reducing water withdrawal for irrigation and other purposes where too much is taken.

10.2bn

How many people we could feed sustainably, in theory

Farms could be expanded in areas where these limits aren't being exceeded.

It could, for example, mean restricting fertiliser use in parts of China and central Europe, and expanding it in parts of sub-Saharan Africa and the western US (*Nature Sustainability*, doi.org/djt7).

Such changes would allow the sustainable production of enough food for 7.8 billion people.

Reductions in food waste and a shift away from eating meat could increase this to 10.2 billion, slightly more than the projected world population in 2050. ▮

Michael Le Page

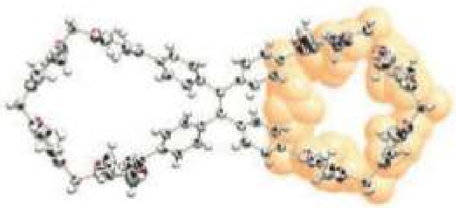
Chemistry

Bow tie-shaped molecules change colour in toxic air

Alice Klein

A MOLECULE that looks like a tiny bow tie and changes colour under different conditions could be used to monitor air for toxic substances.

Huan Cong at the Technical Institute of Physics and Chemistry in China and his colleagues made the substance, which they named BowtieArene, using a pair of pentagon-shaped molecules called pillararenes. These were joined together to create the final product using a fluorescent molecule called tetraphenylethylene. This formed the "knot" of the bow tie.



BowtieArene contains a fluorescent molecule

HUAN CONG, TECHNICAL INSTITUTE OF PHYSICS AND CHEMISTRY, CHINA

When the team mixed individual bow-tie molecules together, they stacked neatly on top of each other. The resulting orderly crystals interacted with light to produce blue fluorescence.

In contrast, when the researchers broke these ordered structures apart, by mechanically grinding or scratching the crystals, the separated bow ties emitted green or yellow fluorescence.

Next, they showed they could make the bow ties blue again by exposing them to the vapour of a toxic chemical called xylene, which pulled the individual molecules back into an orderly arrangement (*Angewandte Chemie International Edition*, doi.org/djt9).

This colour-switching property could be used to make sensors that detect various harmful chemicals in the air, says Cong. His team is currently designing variants of the bow-tie molecule that are capable of identifying the presence of different substances. ▮

Artificial intelligence

An AI learning technique also works in brains

Donna Lu

DEVELOPMENTS in artificial intelligence often draw inspiration from how humans think, but now AI has turned the tables to hint at a way our brains learn.

Will Dabney at tech firm DeepMind in London and his colleagues have found that a recent innovation in machine learning called distributional reinforcement learning also provides a new explanation for how the reward pathways in a brain work. These pathways govern our response to pleasurable events and are mediated by neurons that release the chemical dopamine.

"Dopamine in the brain is a type of surprise signal," says Dabney. "When things turn out better than expected, more dopamine gets released."

It was previously thought that these dopamine neurons all responded identically, "kind of like a choir but where everyone's singing the exact same note", says Dabney.

But the team found that individual dopamine neurons actually seem to vary. Each one is tuned to a different level of optimism or pessimism. "They all end up signalling at different levels of surprise," says Dabney. "More like a choir all singing different notes, harmonising together."

The process that inspired the revelation, distributional reinforcement learning, is one of the techniques that AI has used to master games such as Go and *Starcraft II*. This is the idea that a reward reinforces the behaviour that led to its acquisition. It requires an understanding about how a current action leads to a future reward. For example, a dog may learn the command "sit" because it is rewarded with a treat when it does so.

Previously, models of reinforcement learning in both AI and neuroscience focused on learning to predict an "average" future reward. "But this doesn't reflect reality as we experience it," says Dabney.

"When someone plays the lottery, for example, they expect to win or they expect to lose, but they don't expect this halfway average outcome that doesn't necessarily really occur," says Dabney.

When the future is uncertain, the possible outcomes can instead be represented as a probability distribution: some are positive, others negative. AIs that use distributional reinforcement learning algorithms are able to predict the full spectrum of possible rewards.

"It's a nice example of how computational algorithms can guide us in what to look for"

To test whether a brain's dopamine reward pathways also work via such a distribution, the team recorded responses from individual dopamine neurons in mice trained to perform a task. During training, the mice were given rewards of varying and unpredictable sizes.

Different dopamine cells showed reliably different levels of surprise (*Nature*, doi.org/ggh5kw).

"Associating rewards to certain stimuli or actions is of critical importance for survival," says Raul Vicente at the University of Tartu in Estonia. "The brain cannot afford to throw away any valuable information about rewards. It's a nice example of how computational algorithms can guide us in what to look for in neural response." However, more research is needed to demonstrate whether the results apply to other species or to certain regions of the brain, he says. ▮

TEK IMAGE/SCIENCE PHOTO LIBRARY

Artificial intelligence may teach us about how human brains work

Environment

Australia's fire-driven storms are smoking up the stratosphere

Adam Vaughan

THUNDERSTORMS generated by the intense heat of the bushfires burning in Australia have probably carried as much smoke into the stratosphere as a volcanic eruption.

Blazes across the country in the past few weeks have been so powerful they have generated their own weather. They create rising air that carries ash and smoke and results in the formation of thunderclouds called pyrocumulonimbus (pyroCbs) above the fires.

Some of these clouds are strong enough and rise high enough to have channelled smoke into the stratosphere – a stable layer of air between 10 and 50 kilometres up where particles can get trapped and persist for half a year or longer. Smoke from the fires has moved eastward in the stratosphere and made a full circuit around the world, according to NASA.

There were at least 20 pyroCbs between 28 and 31 December, and more on 4 January, some of which put smoke into the stratosphere. The scale of the smoke there has now been calculated by David Peterson at the US Naval Research Laboratory, who presented his preliminary findings to the American Meteorological Society at a meeting in Boston last week.

"It's very likely on a volcanic scale," he says. Peterson estimates the effect is similar to a moderate eruption, rather than on the scale seen after the massive 1991 eruption of Mount Pinatubo in the Philippines, the largest in modern times. He has done similar work on the impact of pyroCbs before. He found that Canadian wildfires in 2017 put as much smoke as a volcano into the stratosphere.

While it is well known that a volcanic eruption can put enough particles into the atmosphere to have a cooling effect, the different chemistry of pyroCbs means the impacts of the fires on global temperatures aren't yet clear.

They may have a warming or cooling effect, and it isn't known how long the smoke will persist.

Smoke from the Australian wildfires has circled the globe

NASA

Peterson says the biggest question is what role pyroCbs are playing in the climate system. Some of the smoke plumes carried by these clouds are also getting high enough to affect the ozone layer, which is usually at least 15 km up.

We may have a better idea of the smoke's impact soon, thanks to NASA flying a plane earlier this year through the upper level of a pyroCb generated by US wildfires. "It wasn't as massive as these Australia plumes but fortunately at an altitude the aircraft could get to," says Peterson. That research will reveal more about relevant atmospheric chemistry in the clouds. Combined with satellite data, this should give us a clearer idea of what to expect.

Alan Robock at Rutgers University in New Jersey says if the smoke has a cooling effect, it is unlikely to be huge at a global level, but could cause cooling of several degrees C at a local level. If the Australian pyroCbs produce twice as much smoke as those from Canada in 2017, "it still would not be a large or long-lasting impact on climate," he says. ▮

Physiology

Brunch at the weekend messes with our bodies

EATING meals later on weekends than during the week may cause weight gain by disturbing the body's metabolic rhythms.

Disrupted sleep patterns are linked to weight gain, probably because our bodies aren't used to processing food eaten at night, which seems to lead to the storage of extra fat.

María Fernanda Zerón-Rugerio and Maria Izquierdo-Pulido at the University of Barcelona in Spain wondered if eating meals later on weekends might have similar effects. "It's common to sleep in on weekends, so we end up having breakfast later and then lunch and dinner tend to be a bit delayed too," says Zerón-Rugerio. "We call this eating jet lag."

Their team surveyed more than 1100 university students in Spain and Mexico to find out what time they normally ate on weekdays and weekends. Almost two-thirds had an hour or more of eating jet lag on weekends, meaning the midpoint between their first and last meal was at least an hour later on weekends than on weekdays. Breakfast was the most delayed meal, tending to become brunch.

Students with greater eating jet lag were more likely to be overweight. Those who reported more than 3.5 hours of eating jet lag on weekends had higher body mass indexes on average than those with no eating jet lag, regardless of their diet or how much they slept or exercised (*Nutrients*, doi.org/djsc). The difference was equivalent to 4 kilograms in someone who is 170 centimetres tall and weighs 90 kilograms.

> **"Your biological clock doesn't know it's the weekend. It gets confused when you eat later"**

Eating jet lag is probably linked to weight gain because our internal biological clocks, known as circadian systems, prepare our metabolisms to process food at specific times, says Izquierdo-Pulido. If you usually eat breakfast at 7 am, but at 9 am on weekends, "your biological clock doesn't know it's the weekend," she says. "It gets confused when you eat at 9 am." ▮

Alice Klein

Darwin's Galapagos with Jo Ruxton

Explore the Galapagos Islands from the comfort of a luxury small-berth yacht accompanied by marine conservationist and documentary producer Jo Ruxton

A paradise for natural history, animal and geology lovers, we have curated a distinctive trip which includes the UNESCO World Cultural Heritage Site of Quito followed by eight days exploring at sea and exclusive behind the scenes access at the Galapagos Science Centre. The spacious and stylish yacht Natural Paradise is small enough to get into bays that larger expedition ships cannot go near, so you get to experience Galapagos as Darwin did.

Galapagos sea lions, marine iguanas lounging on the shores, blue-footed boobies patrolling the skies, giant tortoises, sally lightfoot crabs and green sea turtles are just a few of the animals native to this fascinating archipelago.

Highlights of the tour include:

- **Explore eight varied islands including Isabela, Espanola and Fernandina**
- **Exclusive behind the scenes access at the Galapagos Science Centre**
- **Jo Ruxton will give talks on board covering marine conservation as well as accompanying the daily excursions**
- **Local naturalist guides will accompany the voyage and give seminars at sea and on land**
- **Lots of opportunities to visit the many islands by panga boat and snorkel in these amazing waters**
- **Observe a wide variety of wildlife including reef sharks, nazca, blue-footed boobies, sea lions, Galapagos penguins, seahorses, sea turtles and the strange yet fascinating mola.**
- **Explore Latin America's largest and best-preserved historic centre and colonial quarters in Ecuador's capital, Quito**

newscientist.com/tours

Departing:
7 June 2020
11 days for £6,995 (approx $8,885)

To book call
+44 1285 601 571
(UK hours Mon to Thu 9-5:30 Fri 9-5 GMT)
Or email
newscientist@steppestravel.com

In partnership with Steppes Travel

SteppesTravel

Palaeontology

AI rethinks mass extinctions

Machine learning sheds new light on the history of life on Earth

Michael Le Page

THE best record yet of how biodiversity changed in the distant past has been created with the help of machine learning. Among other things, it confirms that one of the five great mass extinctions didn't really happen.

It was thought the oceans turned toxic around 375 million years ago, near the end of the Devonian period, wiping out many marine species including almost all trilobites. But the latest study shows no evidence of a sudden catastrophic change like the asteroid impact that wiped out the dinosaurs.

"The late Devonian mass extinction isn't there," says Doug Erwin at the National Museum of Natural History in Washington DC. Instead, there was a gradual decline over around 50 million years.

Fossils are used to date rocks. Because most species are only around for a few million years, if fossils of one species are in rocks from different places, those rocks must be roughly the same age.

Roughly really does mean roughly, though. Previous studies have only been able to divide the past into huge chunks around 10 million years long.

Now Shuzhong Shen at the Nanjing Institute of Geology and Palaeontology in China and his colleagues, including Erwin, have produced an improved record in which each chunk is just 26,000 years long. Using a statistical approach created a decade ago, they analysed 100,000 records of 11,000 marine species whose fossils have been found in China and Europe (*Science*, doi.org/djmn).

Machine learning shows one of Earth's five mass extinctions didn't happen

This is so computationally intense it would take dozens of years to do on a normal computer. So, the team developed machine-learning procedures and ran them on the Tianhe-2 supercomputer.

The record covers 300 million years, from the Cambrian period starting 540 million years ago to just after the start of the Triassic period 240 million years ago.

WLAD74/GETTY IMAGES

The improved resolution is like going from considering all people who lived in the same century as contemporaries to considering only people who lived in the same period of several months to be so.

"The mid-late Devonian diversity decrease is still very clear, but it is spread through the whole time and not concentrated in a single mass extinction," says palaeontologist Richard Bambach, now retired. He argued in a 2004 paper that there was no late Devonian mass extinction.

The idea that there were five great mass extinctions when most plant and animal species on Earth died out was first proposed in a 1982 paper. Later studies have suggested there were between three and 20.

There is no formal definition of a mass extinction, but most biologists would agree that they involve a spike in extinctions over a relatively short time. At the end of the Permian period about 250 million years ago, for instance, most species died out in just 63,000 years, this new analysis shows.

Security

Odd US drone sightings leave authorities baffled

MYSTERIOUS drone swarms have been seen flying at night in Colorado, Nebraska and Wyoming since December, sometimes over locations believed to house nuclear missile silos. A federal task force has been formed to investigate.

The Phillips County Sheriff's Office in Colorado reported the first drones on 20 December. There have been hundreds of sightings since, some of drones flying in a grid formation.

Some observers assumed the drones were part of a military exercise, but the US Air Force has denied involvement. There is no evidence of malicious intent, although the drone operators are breaking US regulations governing flying at night.

The drones are described as resembling model aircraft, with a wingspan of around 2 metres. None has been recovered or even photographed. Similar drones are widely available online for a few hundred dollars.

Robert Bunker of the US Army War College's Strategic Studies Institute in Pennsylvania says the scale of operation suggests it is the work of an organisation such as a university or government, rather than a lone individual – assuming the drones actually exist.

"The first question that the task force has to rule out is if we are not dealing with social media hype. Have these drone swarm sightings now turned into an urban legend?" says Bunker.

2

Estimated wingspan of the unknown drones, in metres

Richard Gill of UK company Drone Defence says that real sightings may have resulted in a number of false reports. "People become hypersensitive after a scare," he says. "Everything with a flashing light will get reported."

Small drones are elusive though, and taking photos of them at night is virtually impossible. Even locating them with radar is difficult.

While the task force is said to be looking at getting a fix on a radio controller on the ground, Gill says its best bet may be to bring a drone down, probably with a jammer.

David Hambling

Medical drugs

'Disturbing' number of sedatives prescribed in the US

Jessica Hamzelou

BENZODIAZEPINE drugs are prescribed at about 66 million doctors' appointments a year in the US, according to a report by the US National Center for Health Statistics. This means that for every 100 adults visiting an office-based doctor, 27 visits result in a prescription for a benzodiazepine.

The figures are based on surveys conducted between 2014 and 2016. "The statistics we have are disturbing, and everyone should be concerned about bringing them down," says Lois Platt at Rush University in Chicago.

Benzodiazepines are sedatives often prescribed for sleep disorders and anxiety. They can be addictive and overdoses can be fatal.

A third of the recorded US benzodiazepine prescriptions were given alongside a prescription for an opioid painkiller. This is especially concerning, because it is easy to overdose when taking the drugs together, says Rebecca McDonald at King's College London. "Benzodiazepine deaths have gone up substantially over the past two decades in the US," she says. "Almost all cases also involved opioids."

"Our finding suggests that most patients prescribed these medications might be long-term users of these drugs," says Loredana Santo at the National Center for Health Statistics.

That is also worrying, says Benedict Hayhoe at Imperial College London. "We should be avoiding using benzodiazepines in the long term."

Platt hopes that prescriptions in the US will start to fall as more people become aware of the dangers of benzodiazepines.

That is what seems to be happening in the UK. A report by Public Health England published last year found a decrease in prescribing rates of benzodiazepines between 2015/16 and 2017/18. ▮

Space exploration

How to sprout a garden on the moon's far side

Donna Lu

CHINA'S Chang'e 4 lunar lander captivated global attention when a cotton seed on board became the first plant ever to germinate on another world – and now the engineer behind this moon garden has revealed just how it was done.

DONNA LU

Xie Gengxin with a replica of his lunar garden

Cotton, *Arabidopsis*, potato and rape seeds, as well as yeast and fruit fly eggs, were all inside a 2.6-kilogram biosphere on Chang'e 4 when it landed on the moon's far side in January 2019.

Months of uncertainty and planning led to the successful mission, says Xie Gengxin at Chongqing University, the experiment's chief designer.

The idea to send a biosphere to the moon was selected from 257 suggestions submitted by Chinese students in 2016.

Rice and *Arabidopsis* have been grown on China's Tiangong-2 space lab and plants have been cultivated on the International Space Station, but those experiments were conducted in low Earth orbit, at an altitude of about 400 kilometres. The cosmic radiation on the moon – 380,000 kilometres from Earth – makes it a more challenging environment.

CHONGQING UNIVERSITY-CLEP

A camera caught a glimpse of seedlings on the moon

Given limited space on the lander, the experiment had to be small and light, says Xie. The cylindrical capsule his team designed was 19.8 centimetres high with a diameter of 17.3 cm. It had a rectangular seedbed inside, measuring 800 cubic centimetres. A pipe in the top allowed sunlight to reach the plants, and the whole capsule was kept at Earth atmospheric pressure.

A replica is currently on display in the Design Museum's Moving to Mars exhibition in London.

The real capsule was powered up just under 13 hours after Chang'e 4 landed, at 11.19 pm on 3 January. The first order of business was remotely watering the seeds with a measured spritz of 18 millilitres.

The team had to consider in advance a number of things that could go wrong during the mission. In addition to camera or data transmission failures, these included the possibility that the water might be released too early or not at all, or that the pipe to let in sunlight might get blocked by moon dust.

The capsule's two cameras photographed the seedbed every 10 hours. Images confirmed that the seeds weren't watered before Chang'e 4 launched from Earth and that none of the seeds had sprouted prematurely.

Once on the moon, the cotton plant sprouted two leaves and its root system grew horizontally rather than down into the soil, probably as a result of the weak lunar gravity. The rape and potato seeds also sprouted on the moon.

The team is uncertain whether the fruit fly eggs hatched, says Xie – if they did, they weren't caught on camera.

The temperature on the surface of the moon reaches highs of 127°C in daytime. But by using two cooling plates, the team was able to limit the daytime temperature inside the biosphere to under 36.5°C. The plant lived for the equivalent of nine Earth days, until the moon's far side turned away from the sun. Temperatures on the moon drop to -173°C during the lunar night, which lasts for a fortnight.

> **"If astronauts can see living, green things in space, it's sure to raise their spirits"**

Although the team knew the plant wouldn't survive the cold, the capsule wasn't powered down until 9 May. After months of experimentation, the capsule had lost some air, with a pressure reading of 0.9 Earth atmospheres.

Future research will focus on how to improve and cultivate more ecosystems in space, says Xie. "If astronauts or space tourists can breathe oxygen generated by plants and see living, green things in space, it's sure to raise their spirits," he says. ▮

Biology

All complex life may have come from spider-shaped microbes

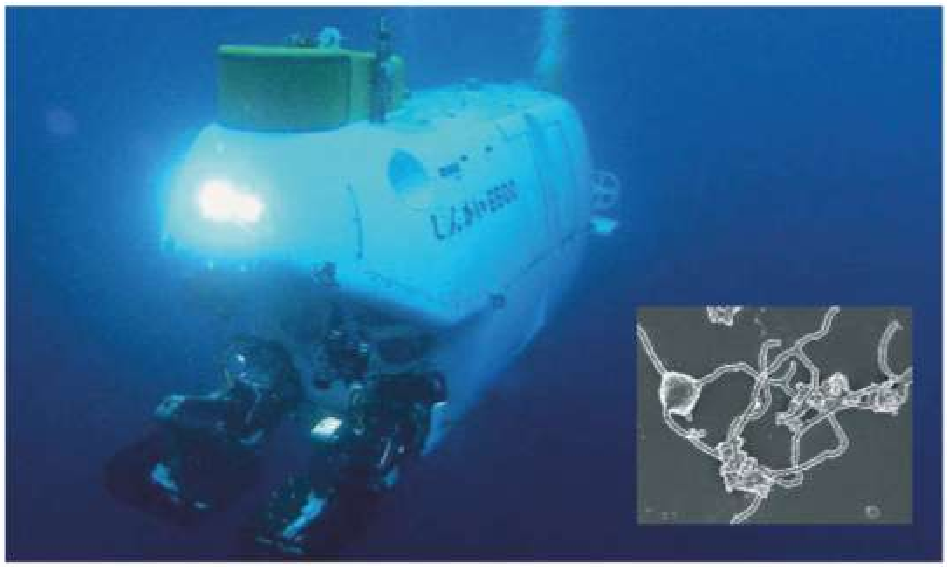
Michael Marshall

WE ARE beginning to better understand the single-celled organisms that may be the ancestors of all complex life.

Last year, Hiroyuki Imachi at the Japan Agency for Marine-Earth Science and Technology and his colleagues isolated a strain of Asgard archaea and grew it in a lab for the first time. That achievement has now been published (*Nature*, doi.org/gghwjg), and a slew of recent studies is giving us more insight into the features of our possible ancestor.

The first Asgard archaea were described in 2015 after their DNA was found in sediments on the Atlantic seabed. Biologists immediately recognised that they could help explain one of the most important steps in evolutionary history: the origin of eukaryotes.

Bacteria and archaea are both old, single-celled branches of life with simple internal structures. But all multicellular organisms are eukaryotes, which have larger, more intricate cells that evolved more recently.



JAMSTEC; HIROYUKI IMACHI/SUGAR/X-STAR/JAMSTEC

Deep-sea vehicles have discovered Asgard archaea (inset) in sediments

While the Asgard microbes are archaea, they carry genes previously found only in eukaryotes. This implies that billions of years ago, eukaryotes evolved from an Asgard archaeon.

The link between them looks increasingly solid. In December, Tom Williams at the University of Bristol, UK, and his colleagues analysed more than 3000 gene families in archaea and eukaryotes. They confirmed that Asgard archaea are the closest known relatives of eukaryotes (*Nature Ecology & Evolution*, doi.org/ggd7k4).

The most crucial feature of eukaryotes is mitochondria: sausage-shaped structures within the cells that provide energy. Mitochondria were once bacteria, which were somehow engulfed by a eukaryotic cell.

The cultured Asgard archaeon, *Prometheoarchaeum*, hints at how this happened. When Imachi and his colleagues grew it, they saw long, tentacle-like protrusions (see inset image, left). The team suggests that Asgard archaea cooperated with bacteria, which first lived swaddled in these protrusions, before ultimately moving inside the Asgard cells.

Robert Robinson at Okayama University in Japan and his team found that Asgard archaea also have mechanisms for assembling and breaking down a protein called actin (bioRxiv, doi.org/gf8bfc). This forms struts within cells and plays a key role in enabling membranes to swallow other cells. Robinson says the Asgard archaea probably use actin to grow their protrusions.

This can't explain everything, says Purificación López-García at the French National Centre for Scientific Research. She says the outer membranes of eukaryotes resemble those of bacteria, not archaea. Many eukaryotic genes also come from bacteria. She suspects that more than two types of microorganism contributed to eukaryotes. ▮

Find out more about our long-lost microbial ancestors in next week's issue.

Conservation

Many orangutans released into the wild don't survive

THE number of Bornean orangutans is dwindling, and there is little evidence that efforts to relocate them from risky areas or rehabilitate those in captivity bolster their population.

Between 2007 and 2017, about 1200 Bornean orangutans (*Pongo pygmaeus*) were released into natural forests in Kalimantan, the Indonesian part of Borneo. Nearly 500 of those were formerly captive and nursed back to health before being released. But it is unclear how many of these animals are still alive.

To make these estimates, Julie Sherman at Wildlife Impact in Oregon and her team reviewed studies, news stories and public data on conservation efforts. They also collected data from rescue centres, government agencies and zoos on the outcomes of relocation or rehabilitation for these apes.

The few cases where orangutans were tracked for more than three years suggest that fewer than 30 per cent of the released animals may have survived.

During the study period, at least 620 wild orangutans were also picked up outside protected areas in Kalimantan and released into a different wild site, mainly to prevent potential conflict with people.

"The assumption translocation practitioners make is that since these are wild orangutans, they will survive anywhere in the wild," says Sherman. Again, the fate of such animals usually isn't monitored.

30%

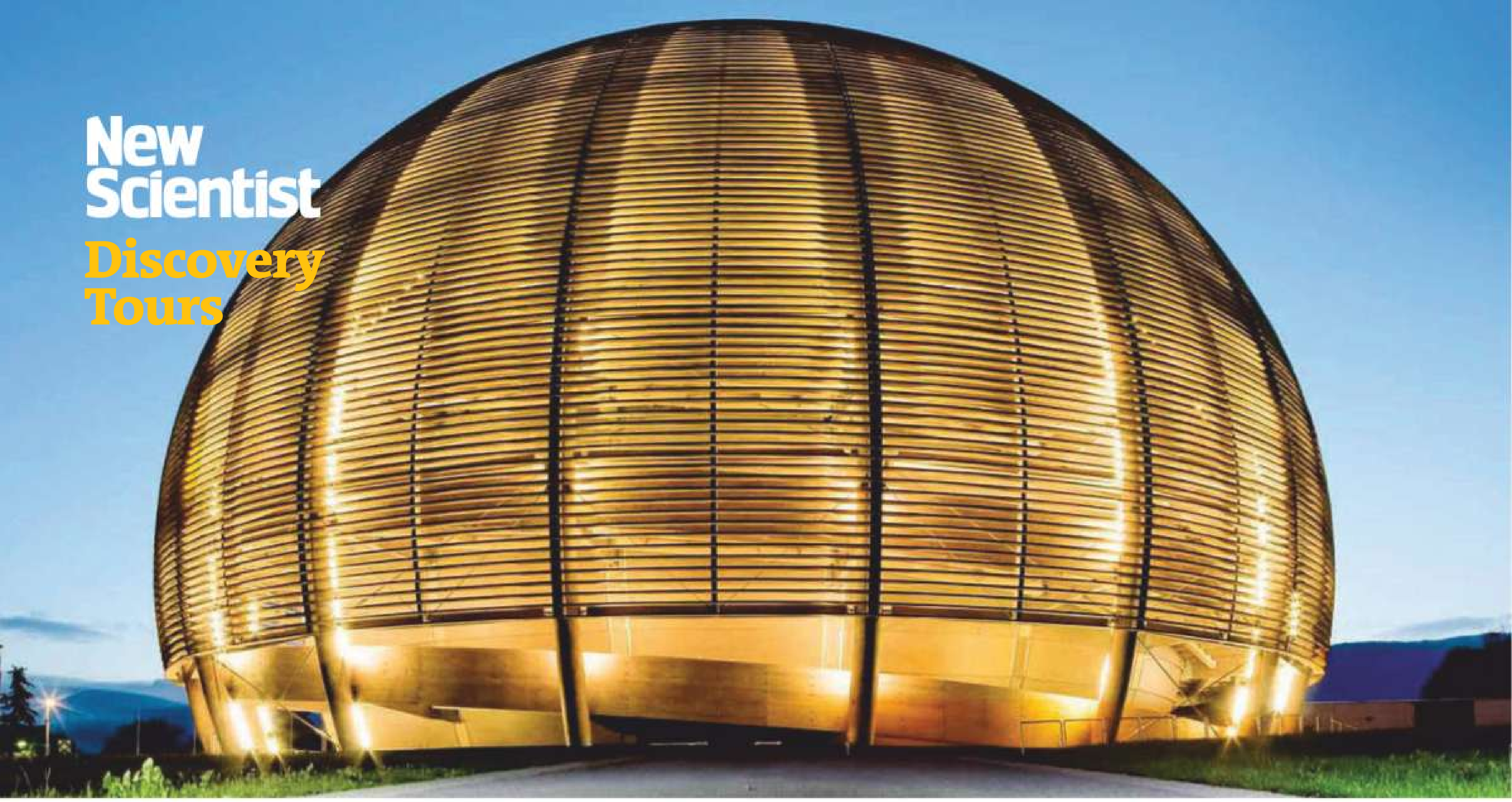
Proportion of released orangutans that may survive for three years

The researchers found that, in most cases, people weren't tracking the impacts of conservation actions (*Biodiversitas*, doi.org/djs5).

Their analysis of spending by 145 organisations in 2016 showed that rescue, reintroduction and translocation was the predominant conservation strategy for Bornean orangutans, with more than £3.8 million allocated to it.

Instead of improving the status of this ape, however, the species went from being classified as endangered to critically endangered in 2016. ▮

Shreya Dasgupta



SWITZERLAND / FRANCE

Explore dark & frozen matter: CERN & Mont Blanc

Particle physicist Dr Darren Price and science journalist Laura Spinney will lead a fascinating and insightful tour focusing on CERN, home to the famous Large Hadron Collider, and Mont Blanc to investigate receding glaciers. Fall in love with the charming lakeside city of Geneva, famous for its watch-making, high quality chocolate and enchanting old town.

Tour highlights include:

- **Evening talks and walking seminars with Dr Darren Price and Laura Spinney**
- **CERN guided tour to learn about the groundbreaking work being carried out**
- **Walking tour of Geneva's old town centre and beautiful cruise on Lake Geneva**
- **Cable-car trip to the top of the Auguille du Midi overlooking Mont Blanc**
- **The stunning botanical gardens**
- **Visit the beautiful small town of Chamonix and then on to Mer de Glace to witness an ice cave carved into the glacier itself**
- **Trip to Geneva's Museum of the History of Science, which features astronomy, microscopy and meteorology exhibits**

**No single supplements for the first two solo travellers on each departure.
There are only 22 places available per tour, which are expected to fill up very quickly.
Please enquire early to secure your place.**

To book call +44 207 593 2284

(UK office: Mon-Fri 9am to 6pm, Sat 9am to 4pm GMT)

Or email culturaltours@kirkerholidays.com

newscientist.com/tours

Departing:
18 May 2020
17 September 2020
6 days for £2,699 (approx $3,429)

In partnership with Kirker Holidays

Kirker ABTA ABTA No.V6595 AITO Assured

KLEIN & HUBERT/NATURE PL

Animal behaviour

Howl's that! We've seen wolf pups fetching balls

RETURNING a thrown ball is one of the most quintessential dog behaviours. But research suggests that it may predate dogs, as some wolf pups seem to enjoy the game.

The first observations of wolf pups fetching balls for people happened unexpectedly, says Christina Hansen Wheat at Stockholm University in Sweden.

Her team studies the behavioural changes involved in domestication by looking at dogs and wolves. The team hand-reared wolf pups from three litters once they were 10 days old. When they were 8 weeks old, the pups were put through a series of behavioural tests.

One of these involved having an unfamiliar person toss a tennis ball across the room to see how much it captured the pup's attention. Almost all of the pups from the 2014 and 2015 litters flatly ignored the ball. One gave it a passing glance.

The next year, one pup shocked the scientists by not only chasing down the ball and snatching it up, but bringing it back to the person when coaxed.

Hansen Wheat was watching from another room. "I literally got goosebumps," she says, adding that dogs' ability to interpret socially communicative behaviour from people – like following a person's cues to bring a ball back – has been considered a consequence of the domestication process.

In the end, three wolves from the 2016 litter fetched the balls, and one did it on all three trials of the test. Others played with the ball but wouldn't return it (*iScience*, doi.org/djkv). **Jake Buehler**

Mental health

Pregnancy loss can lead to PTSD

ONE in six women who have an early miscarriage or ectopic pregnancy have symptoms of post-traumatic stress disorder nine months later. As people can experience PTSD symptoms for months, it is important they are able to get psychological support should they need it, say the researchers behind the work.

It is estimated that women have more miscarriages than live births over their lifetime. But the psychological effects are often "brushed under the carpet", says Jessica Farren, an obstetrician and gynaecologist at St Mary's Hospital in London.

Women often don't tell their friends, family and colleagues that they are pregnant until after their 12-week scan. If that scan reveals a miscarriage, they may feel unable to tell people, so miss out on support, says Farren.

She and her team asked 737 women who experienced a miscarriage during the first 12 weeks of pregnancy or an ectopic pregnancy – in which the embryo attaches outside the uterus, causing pregnancy loss – to complete questionnaires designed to diagnose anxiety, depression and PTSD. The questionnaires were sent one month after pregnancy loss, and then again three and nine months after the losses.

Nine months after a pregnancy loss, 18 per cent of women met the criteria for a PTSD diagnosis, 17 per cent reported anxiety and 6 per cent of women had symptoms of moderate to severe depression (*American Journal of Obstetrics and Gynecology*, doi.org/djkz).

At the moment, the National Health Service in England doesn't routinely offer psychological support and counselling to everyone who experiences pregnancy loss, says Farren. **Jessica Hamzelou**

Biotechnology

Bricks grown from bacteria can multiply

LIVING concrete made from bacteria could one day help to reduce the environmental impact of the construction industry.

Wil Srubar at the University of Colorado, Boulder, and his team used *Synechococcus* bacteria to create building blocks in a variety of shapes (one is pictured below).

The team combined the bacteria with gelatin, sand and nutrients in a liquid mixture, then placed this in a mould. With heat and sunlight, the bacteria produced calcium carbonate crystals around the sand particles, in a process similar to how seashells form.

COLORADO UNIVERSITY, BOULDER CEAS

When cooled, the gelatin solidified the mixture into a gel. The team then dehydrated the gel to toughen it, with the entire process taking several hours.

The researchers liken the material to concrete – a mix of gravel, sand and cement. But its mechanical properties are closer to mortar, a weaker material usually made with cement and sand, says Srubar.

An advantage of using bacteria to create the concrete is that if it isn't dehydrated entirely, it can still grow. With additional sand and nutrient solution, a growing brick can be split to create two bricks (*Matter*, doi.org/ggh2k9). The process has the potential to make energy intensive concrete production less environmentally damaging because of its reliance on photosynthesis. **Donna Lu**

New Scientist Daily
Get the latest scientific discoveries in your inbox
newscientist.com/sign-up

Really brief

LENTINK LAB/STANFORD UNIVERSITY

Pigeons inspire flying machine

A robot that resembles a pigeon can make tight turns like a bird. PigeonBot is powered by a propeller and has wings that can be controlled remotely. Its average speed is about 40 kilometres per hour, a bit slower than the average pigeon (*Science Robotics*, doi.org/djk4).

Metal has starring role in bond movie

A chemical bond has been filmed breaking and forming for the first time. Researchers fired a beam of electrons at a molecule composed of two atoms of the metal rhenium. A bond between them broke and reformed. The researchers filmed the atoms changing shape as a result (*Science Advances*, doi.org/djsb).

‘The blob’ is blamed for avian massacre

A million seabirds that died along the US west coast were probably the victims of an unprecedented marine heatwave in the Pacific. The killer appears to have been “the blob”, a vast, record-breaking patch of warm water that occurred off the west coast of North America between late 2013 and 2016 (*PLoS One*, doi.org/djk5).

Immunology

Special nose cells sniff out allergens

MICE have thousands of chemical sensing nose cells that can trigger an allergic reaction. Researchers say this discovery could help us fathom how the immune system reacts to allergens we breath in and why some people with allergies lose their sense of smell.

We know that in people and mice, inhaling allergens can cause nasal inflammation. This prompts a further allergic response driven by immune cells, but we don’t fully understand the process.

To try to learn more, Lora Bankova at Harvard University and her colleagues isolated cells from the noses of mice and sorted them according to their shape, size and the proteins on their surface.

They found chemical sensing cells that react to allergens in the air soon after they are inhaled. These cells release molecules that cause inflammation in the nose before immune cells are delivered to the nose in the bloodstream.

Bankova says she was surprised to find mice have up to 30,000 of these nose cells (*Science*, doi.org/djs6). Equivalent chemical sensing cells exist in the human nose, says Bankova, but we don’t know if they have a similar function.

The cells are mostly in the bit of the nose involved in smell, which hadn’t been thought to play a role in allergic responses. This could be why people with chronic allergies can lose their sense of smell, says Bankova. “It might be because there is so much inflammation in that area that we hadn’t recognised.” **Layal Liverpool**

Could weaning babies earlier help ease food allergy risks? See p 20

Space

IRINA DMITRIENKO/ALAMY STOCK PHOTO

Great balls of dust seem to defy pull of vast black hole

CLOSE to Sagittarius A*, the Milky Way’s central, supermassive black hole, six strange objects are defying gravity. They look like clouds of gas and dust, but behave like stars, and scientists don’t know what they are.

The first two of these objects, called G1 and G2, were discovered nearly a decade ago. At the time, astronomers thought they were just gas clouds soon to be gobbled up. But instead of being stretched out and swallowed by the black hole, the clouds continued to orbit it.

Anna Ciurlo at the University of California, Los Angeles, and her colleagues have spotted four more of these weird clouds, which have been called simply G objects. Each of them is on the order of 15 billion kilometres across, and from afar they look like huge clouds that have signatures of hydrogen atoms and don’t emit very much heat.

Like the other two G objects, they are orbiting Sagittarius A* the way stars would, instead of falling in as they would if they were just clouds (*Nature*, doi.org/djmh).

Ciurlo suggests these could be stars hidden by shrouds of gas and dust thick enough to obscure their light, possibly the result of stellar smash-ups in which two stars merge to leave a single large star surrounded by debris. Leah Crane

Bionics

Orange jelly could become robot skin

ARTIFICIAL electrified-skin made of strange orange jelly can sense a touch and heal itself. It could be used to coat prostheses or to cover robots so they can “feel”.

Many types of “e-skin” have been made but are usually limited to flat sheets that attach only to flat surfaces, says Kyeongwoon Chung at the Korea Institute of Materials Science in South Korea.

Chung and his team made an e-skin that can be 3D printed into any shape. They made pyramids, rings and a sort of cap that can fit over a finger. Chung says it would be possible to make a face shape.

The e-skin is made out of an orange, jelly-like substance composed mainly of water and acrylic acid. The gel contains both positively charged and negatively charged particles, so when it is cut or ripped, those particles attract one another and it heals itself.

It can also detect if you touch it. When a weak electric field is applied to the skin via two wires, a touch from a finger or any object that conducts electricity makes current flow through the gel. The difference in the current intensity at each wire allows the point of touch to be identified (*ACS Applied Materials & Interfaces*, doi.org/djsg). **LC**

Immunology

Food fight over allergies

Current baby weaning guidelines may mean we are missing a crucial window to prevent food allergies. **Clare Wilson** reports

ELI ASENOVA/GETTY IMAGES

Parents are advised not to give solid food to babies until they reach a certain age

WHEN you have a child with food allergies, the fear of a severe reaction is always there, says Emma Amoscato. "It's not just mealtimes, it's going to nursery, family events, soft play. It's not something you can ever take a day off from."

She is frustrated that some children, such as hers, could perhaps have avoided developing their allergies at all. A growing body of evidence, including findings that emerged last month, suggests that the earlier babies eat foods like peanuts and eggs, the less likely they are to develop allergies to them.

But in some countries, such as the UK, weaning babies onto solid food early runs counter to official advice to avoid giving infants any solid food until they are 6 months old. Parents face conflicting information from allergy specialists and the healthcare staff they see most often such as family doctors and midwives. "You don't know who to trust," says Amoscato, who is author of *Living with Allergies: Practical tips for all the family*.

The stakes are high, as was highlighted last year by two UK cases in the headlines in which teenagers died from allergic reactions, both caused by meals from a shop or restaurant they thought were safe.

Food allergies are now common. In the UK, for instance, 7 per cent of children now have one, and the number of hospital admissions for severe allergic reactions has risen six-fold in the past 20 years.

Changes in how babies are fed can't be the only explanation, because other allergies such as hay fever and asthma are also on the rise. One idea is a modern take on the hygiene hypothesis, and suggests that this may be because modern life prevents us from encountering many friendly and important microbes during our childhood.

But weaning practices are also under suspicion, because they have changed a lot in the past few decades. It was once common for parents to start giving babies solid food as early as possible to fatten them up, sometimes at just a couple of months old or earlier.

By the 1990s, this was becoming frowned on, partly because doctors thought the gut was too immature. There was also growing concern about the move away from breastfeeding, especially in developing countries where there is higher risk of infections from formula milk made with unsterilised water.

As more was discovered about the beneficial substances in breast milk, such as antibodies that protect against microbes, the World Health Organization released guidelines in 2001 recommending that babies should ideally have nothing but breast milk for their first six months. These were adopted by many countries, including the UK.

At the time, this advice wasn't expected to affect allergies, because the thinking was that we should delay giving potentially risky foods like peanuts to infants for as long as possible. Children known to be at high risk of peanut allergy, such as those with affected siblings, were advised to avoid them until they were 3 years old. Pregnant women were even told not to eat peanuts.

> **"It was once common for parents to start babies on solids as early as possible to fatten them up"**

Then in 2015 came the first randomised trial to look at this question. In 530 children, those who ate peanut snacks before the age of 11 months were much less likely to get peanut allergy than those who waited until the age of 5; the rates were 3 per cent and 17 per cent respectively.

It looked like a wrong turn may have been taken. "All this advice to delay is not just neutral, it's actually harmful," says Gideon Lack at King's College London.

Why would timing matter? The idea is that the immune system learns not to react to things we eat when it first encounters food proteins in the gut. If weaning is delayed and babies first encounter food proteins through their skin, the immune system can become sensitised to these proteins.

There are several strands of evidence for this. One is that babies who have moisturisers or nappy creams based on peanut oil rubbed on their skin have a seven-fold higher rate of peanut allergy. Another is that infants get more allergies if they have eczema, in which skin is inflamed and cracked – although that could just be because eczema is also an allergic condition.

More Insight online
Your guide to a rapidly changing world
newscientist.com/insight

It isn’t just babies with eczema who are at risk, says Helen Brough, also at King’s. Peanut dust stays on the skin for hours, she says. “If the parents have eaten a bowl of peanuts before a nappy change, they’re applying [peanut dust] to the skin.”

At her clinic, she warns parents against using creams based on peanut, almond or sesame oil, for instance. “We say no food on skin.”

Weaning advice has started to change. Multiple US and European bodies, such as the American Academy of Pediatrics and the European Food Safety Authority, now encourage giving potential allergens from 4 months onwards, with the proviso that infants should never be given whole nuts in case they choke.

But the UK hasn’t. One factor is that early weaning clashes with efforts to promote exclusive breastfeeding for a child’s first six months, which is a major focus of child health promotion.

“People may think once you introduce solids you might as well stop breastfeeding,” says Amy Brown at Swansea University, UK.

Population studies show a link between early weaning and formula use – although this may just be a correlation.

Some studies have suggested that breastfeeding brings a wider range of health benefits than just cutting infections, such as reducing obesity and diabetes, although this has been contested.

7%

The proportion of children in the UK with a food allergy

“There are known benefits of exclusive breastfeeding for around the first six months of a child’s life and this is best for overall health,” says Adrienne Cullum at Public Health England.

One UK body that takes a different tone is the British Society for Allergy and Clinical Immunology (BSACI), which has issued guidance urging parents of children at higher risk of allergies, such as those with eczema, to start giving foods from 4 months of age.

BSACI president Adam Fox says this isn’t at odds with official advice, as the full government guidelines say people should aim to introduce food at 6 months old, but not before 4 months, and that higher-risk families should consult their doctor. Those nuances can be lost in advice from healthcare staff and websites and leaflets aimed at parents, which tend to state a blanket 6 months, although many families do start before then. “Parents are feeling quite lost and confused,” says Amoscato.

To help cut through the noise, parents of high-risk children would ideally get tailored advice from specialists, but they are unlikely to get an appointment in time. “If they’re on a waiting list for three or four months, then we have missed that window,” says Lucy Upton, a paediatric dietitian and a spokesperson for the British Dietetic Association. She recommends high-risk families follow the BSACI guidance on how to give potential allergens safely.

Upton hopes that UK weaning advice will be reconsidered after a further trial published last month, which found that high-risk children given six potentially allergic foods between the ages of 3 and 6 months developed fewer allergies than those who got them later. With its clear finding that benefits arise from starting before 6 months, the clash with official advice couldn’t be starker.

When *New Scientist* asked Public Health England if this changed things, a spokesperson said: “We wouldn’t change our advice based on one study – we need to look at the totality of the evidence.”

For Amoscato, the delays are frustrating. “They have done the studies. The delay in the government passing the information on could be putting children’s lives at risk.” ▮

Can allergies be reversed?

Parents can try to reduce the risk of their babies developing allergies (see main story), but once an allergy has developed, there is nothing you can do about it, right? Perhaps not.

One approach being investigated is immunotherapy. This involves giving people gradually increasing amounts of the substance they are allergic to in an effort to reduce their body’s sensitivity to it. It starts off with microscopic amounts and must be done under medical supervision for safety.

Some studies have found that this helps some people, but others have suggested that in the case of peanut allergy, it raises the risk of anaphylaxis, a serious reaction requiring an injection of adrenaline to keep people breathing.

Recent research suggests why: the treatment doesn’t take away the allergy, it just encourages the body to make antibodies against the immune cells that cause the reaction. Protection may also only last while treatment continues, so people would need to keep taking small doses of allergens every day.

Working hypothesis

Sorting the week’s supernovae from the absolute zeros

▲ Alphabet

Google’s parent firm has joined the ranks of trillion-dollar companies, following Microsoft, Apple and Amazon. It still has some way to hit a googol valuation, or $$10^{100}$.

▲ Wollemi pines

A secret firefighter mission has helped to save the only wild Wollemi pines, ancient trees threatened by the Australian wildfires.

▲ Ancient grains

Dust from a meteorite is the oldest known material on Earth. At 7.5 billion years old, the particles are 3 billion years older than the solar system.

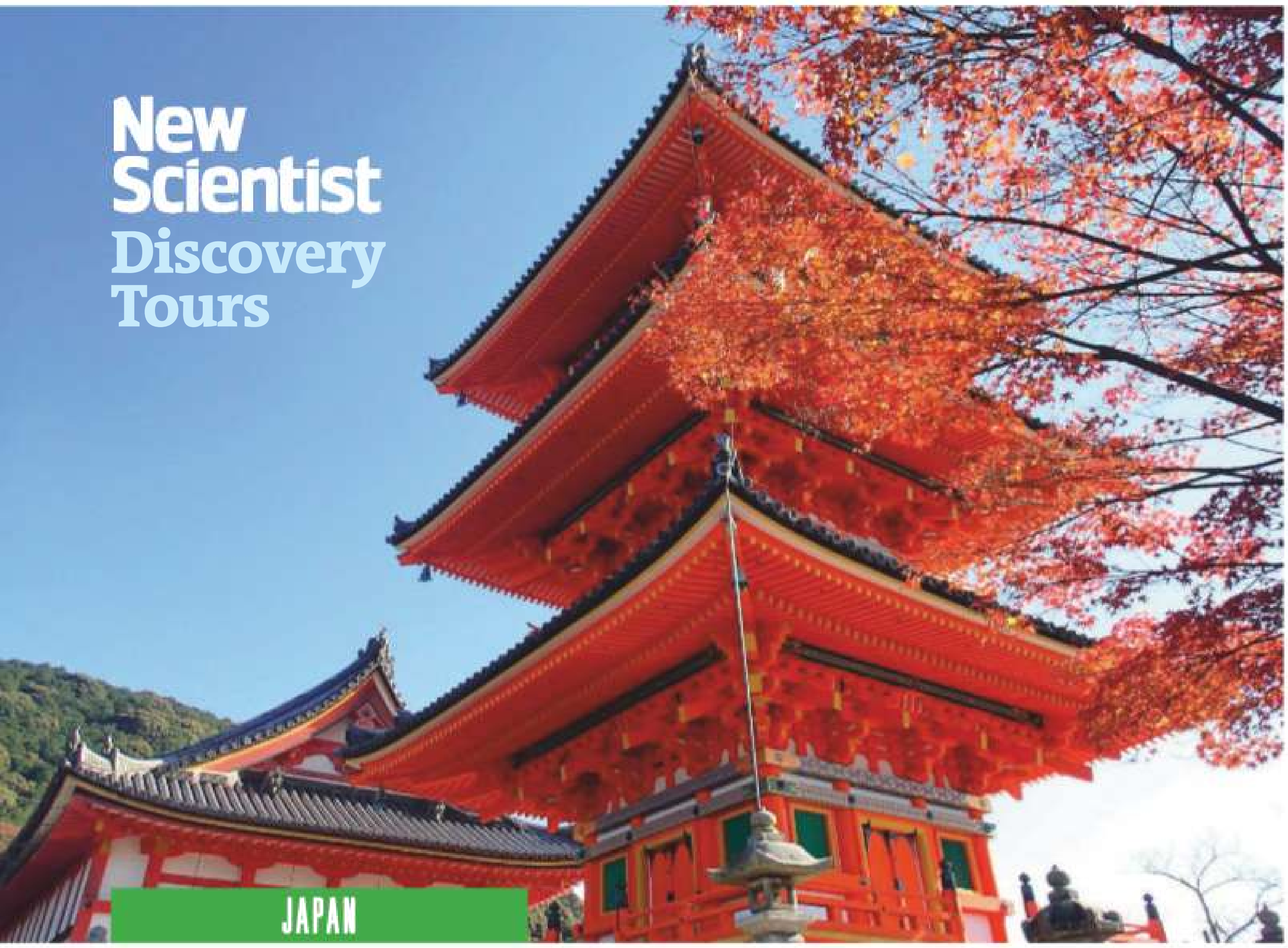
▼ Face recognition

The EU is considering a temporary ban on the use of face recognition in public places. Or we could all just wear balaclavas.

▼ Isle of Wight

One of the six sea eagles released on the southern UK island last year has decided to set up home in landlocked Oxfordshire instead.

TOP: JANECE FLIPPO/ALAMY STOCK PHOTO; BOTTOM: WIM VAN DEN HEEVER/NATURE PL



Japan: Nature, culture, science

Discover Japan on a 12-day tour taking you to Tokyo, Hakone, Kyoto and Kagoshima

In one of world's most technologically advanced countries, visit leading institutions and explore advances in space travel, robotics and AI, whilst witnessing exceptional landscapes, from snow-capped mountains to hot springs and volcanic islands

Tour highlights include:

- **Talks and walking seminars from *New Scientist* head of features Rowan Hooper**
- **Miraikan Museum of Emerging Science**
- **SCMAGLEV and Railway Park**
- **Toyota Museum of Industry and Technology**
- **City tours of Tokyo and Kyoto**
- **Two bullet train journeys**
- **JAXA space museum**
- **A traditional meal with a geisha**
- **The Sakurajima volcano**
- **Sailing on Lake Ashi**
- **National Museum of Nature and Science**
- **Space Museum TeNQ**
- **Zen temples and Shinto shrines**

No single supplements for the first two solo travellers to book. There are only 15 spaces available on this tour, so please get in touch early to ensure you don't miss out.

Departing:
18 October 2020
12 days for £6,695 (approx $8,499)

To book call +44 1285 601 571 (UK hours Mon to Thu 9-5:30 Fri 9-5 GMT)
Or email newscientist@steppestravel.com

newscientist.com/tours

In partnership with Steppes Travel

SteppesTravel

The columnist
James Wong on claims that food is less nutritious **p24**

Letters
Pedestrian-friendly cities need room to play too **p26**

Aperture
Making an artificial glacier in the Himalayas **p28**

Culture
Why civil rights go hand in hand with access to IT **p30**

Culture columnist
Jacob Aron on games that tell the story of evolution **p32**

Comment

Pseudoscience on TV

Alternative health show *The Goop Lab* on Netflix demonstrates just how easy it is to fall for bad science, says **Clare Wilson**

Clare Wilson is the author of Health Check, *New Scientist*'s weekly email newsletter about wellbeing. Sign up at: newscientist.com/sign-up/health

PSYCHIC readings, energy healing and vampire facials are just a few of the adventures had by actor and alternative health guru Gwyneth Paltrow and her team in her new Netflix series *The Goop Lab*. Goop, Paltrow's natural health firm, is already a byword for unrestrained woo, but the TV series takes things to the next level. Instead of turning it off, we should view it to learn how to spot bad science.

Like a car crash unfolding in front of me, once I started watching the show I couldn't look away. In fact, it is so bad it is good: a masterclass in how to use logical fallacies, non sequiturs and cherry-picking to defend pseudoscience.

Take the episode on energy healing, also known as Reiki healing. Practitioners say they can see and manipulate energy fields around people's bodies that are invisible to the rest of us.

JOSIE FORD

This looks as outlandish as it sounds. While the "patient" lies on a massage table, the practitioner touches or waves his hands over their body to twiddle their fields into place. Members of the Goop team jerk and arch their backs – they are either true believers or are going to heroic lengths to suck up to their boss. Most say they feel better afterwards, although one says it felt like an exorcism.

As proof that it works, the show wheels out a 57-year-old man who says the technique cured him of numbness in his legs after cancer treatment. But this kind of nerve damage often fades with time, and the show doesn't say how many people try it without success.

The practitioner says "the technology's not quite there to measure energy healing" – a textbook evasion. While we may not be able to quantify these apparent energy fields, there is nothing to stop measurement of the healing part in a randomised controlled trial. The team also cites quantum physics and the double-slit experiment, which shows that light can act like both waves and particles, although the relevance of this to energy healing is unclear.

These kinds of alternative therapies may seem harmless, but when people rely on them to treat serious illnesses it can be deadly. People with cancer who use complementary therapies tend to reject conventional treatment and so can be less likely to survive their disease than those who don't. The show states at the beginning of each episode that people shouldn't take it as medical advice, but the impact of a 10-second disclaimer seems tiny compared with half an hour of beautiful Californians saying how awesome they feel.

In another episode, Paltrow's personal medium comes on and claims to be getting messages from the dead. She calls out a few initials and words, a lot of which don't hit home, but the few that do provoke open-mouthed admiration from the Goop team.

Paltrow also has a vampire facial during the series, in which her face is injected with platelet-rich plasma made from her own blood. It's true, as the show claims, that platelets contain substances that promote healing. But despite intense efforts, practitioners have failed to show platelet-rich plasma has convincing effects on tissue repair in large, randomised trials.

The most annoying part of the show for me is when Paltrow paints resistance to her credo as anti-feminist, when the Goop website feels like an online version of the most regressive women's magazine, telling readers they need to spend time and money on diet and beauty regimes. Paltrow complains that women face pressure to "look a certain way". It's a bit rich from a Hollywood actor who flogs £125 face creams.

Still, Goop was valued at a quarter of a billion dollars in 2018, so Paltrow has clearly found an effective business model. She was quoted in *The New York Times* as saying that controversies just led to more people visiting her website, letting her "monetise those eyeballs". It's hard not to suspect that criticism of *The Goop Lab* won't bother Paltrow one bit. ▮

#FactsMatter

The great nutritional collapse Claims that our food is becoming less nutritious are often bandied about, but the truth is far more complicated, writes **James Wong**

James Wong is a botanist and science writer, with a particular interest in food crops, conservation and the environment. Trained at the Royal Botanic Gardens, Kew, he shares his tiny London flat with more than 500 houseplants. You can follow him on Twitter and Instagram @botanygeek

James's week

What I'm reading
As usual, an awful lot of very dry academic journals. The data tables are the best bit.

What I'm watching
Mindhunter *on Netflix. Often with my hands over my eyes.*

What I'm working on
Filming a new documentary series for the BBC.

This column will appear monthly. Up next week: Chanda Prescod-Weinstein

YOU could be forgiven for thinking we are living in the midst of a nutritional apocalypse. "You'd have to eat 10 tomatoes today to get the same level of nutrients as one in the 1950s," declared an activist on the radio recently.

On Twitter, there was more of the same: "One would have to eat eight oranges today to derive the same amount of vitamin A our grandparents would have gotten from one." And at a farming conference, a speaker proclaimed that modern farming means that fruit and vegetables have been "drained of their nutrients", showing falls of "up to 50 per cent over 50 years". But what evidence are these claims based on? I thought I'd better take a closer look.

Perhaps the most commonly cited study used to support this narrative is a 2004 paper in the *Journal of the American College of Nutrition*. It analyses nutritional data for 43 garden crops in the US from 1950 and 1999. But scan the results and a rather different picture emerges to the popular idea that modern food is lacking.

Instead of showing a nutritional collapse across the board, the research found only about half of the 13 nutrients checked showed a statistically reliable decline, while others remained unchanged. For those nutrients that were found to have declined, the falls reported across all 43 crops ranged from a modest 6 per cent for protein to a 38 per cent drop for riboflavin, which is a B vitamin.

What about the 90 per cent reduction in the overall nutrient levels in tomatoes I had heard? Well, no such figure appears to exist in this study. The single largest fall in the study, which was in an individual tomato crop, appears to be a 54 per cent drop in calcium, however most other vitamins and minerals stayed pretty stable. What about the "eight oranges" claim for vitamin A? Oranges weren't even part of the study, so it is unclear exactly where that statistic originated.

And the 2004 study is only so reliable. In the decades between the 1950 and 1999 data sets it used, everything from crop varieties and testing techniques have changed significantly. So this type of study is unlikely to be a like-for-like comparison. This was something the authors were careful to point out: "There is no way that you can reliably measure the decline for single foods." This is the opposite of what I keep hearing.

> **"If the nutrient levels in modern crops had collapsed to the degree claimed, it would be clear in the human population"**

Is there any other evidence on nutrient changes? The Broadbalk Wheat Experiment is a pioneering study that has been gathering samples of wheat grown in the same field in England for 175 years, making it the world's longest running agricultural trial. Between the 1800s and the late 1960s, the nutrient levels in the grain grown there stayed relatively stable. However, from then onwards there have been significant falls, especially for minerals like zinc and iron, which neatly coincided with the introduction of a modern variety of wheat. These findings are potentially concerning.

But while it was an excellent review of the nutrient content for a single crop in a single field in one place, extrapolating its results as representative of all crops across the whole world, or frankly even the same wheat variety in the next county, are problematic. Trials have shown, for example, that identical types of wheat grown in two different fields in the same US state can show an eight-fold difference in key minerals like selenium. Such a difference far outweighs the declines observed in the English single-field study.

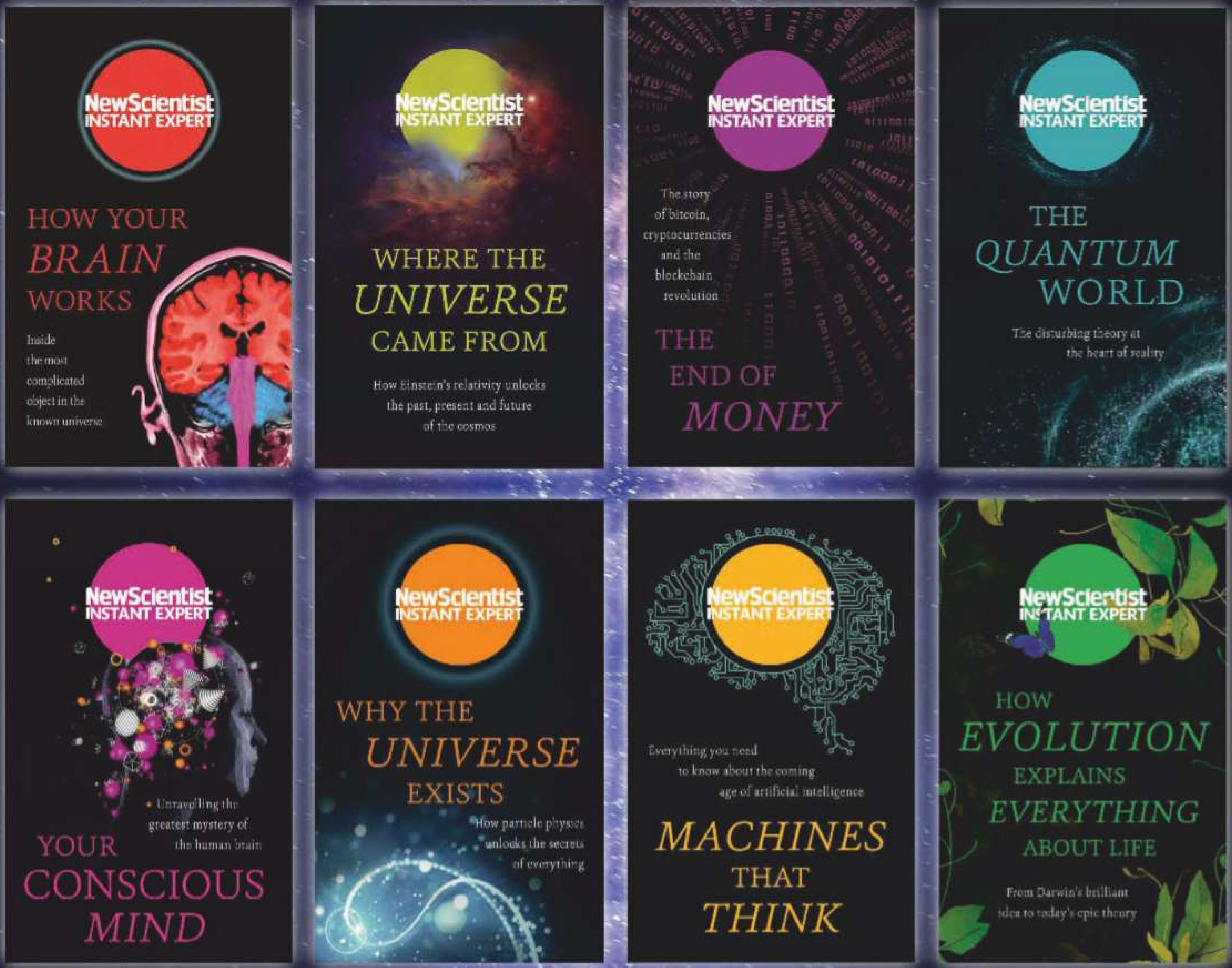
Arguably the best evidence comes from studies that grow historical and modern varieties side-by-side in the same fields, replicating the exercise at various locations. Results have been mixed. In one study by the US Department for Agriculture, broccoli didn't show a clear trend nutritionally speaking either way in terms of differences between old and new varieties. While nutritional differences were recorded in terms of the size of the broccoli head, factors such as weather showed an effect on nutritional content up to 10 times greater than crop size. For wheat, while some nutrients did decline in newer varieties, many were stable. This suggests a far more complex picture than many have claimed.

Most pertinently of all, if the nutrient content of crops had indeed collapsed to the degree so frequently claimed, this would be clear in terms of human health. Yet nutrient deficiencies have actually declined worldwide by roughly 40 per cent since 1960, according to a University of California study, and by as much as 80 per cent in regions like east Asia. This was partially due to fortification of foods, but mainly attributed to modern agriculture resulting in a more diverse diet. It seems modern farming isn't quite the dietary demon some say it is.

I for one can't wait to see what further research uncovers, but there is no need to panic just yet. ■

INTRODUCING THE
New Scientist
INSTANT EXPERT SERIES

DEFINITIVE, ENGAGING AND ACCESSIBLE GUIDES TO
THE MOST IMPORTANT SUBJECTS IN SCIENCE.


NewScientist INSTANT EXPERT
HOW YOUR BRAIN WORKS
Inside the most complicated object in the known universe
NewScientist INSTANT EXPERT
WHERE THE UNIVERSE CAME FROM
How Einstein's relativity unlocks the past, present and future of the cosmos
NewScientist INSTANT EXPERT
The story of bitcoin, cryptocurrencies and the blockchain revolution
THE END OF MONEY
NewScientist INSTANT EXPERT
THE QUANTUM WORLD
The disturbing theory at the heart of reality
NewScientist INSTANT EXPERT
Unravelling the greatest mystery of the human brain
YOUR CONSCIOUS MIND
NewScientist INSTANT EXPERT
WHY THE UNIVERSE EXISTS
How particle physics unlocks the secrets of everything
NewScientist INSTANT EXPERT
Everything you need to know about the coming age of artificial intelligence
MACHINES THAT THINK
NewScientist INSTANT EXPERT
HOW EVOLUTION EXPLAINS EVERYTHING ABOUT LIFE
From Darwin's brilliant idea to today's epic theory

NewScientist newscientist.com/instant-expert-books

Editor's pick

Pedestrian-friendly cities need room to play too

21/28 December 2019, p 10

From Rob Wheway, Coventry, West Midlands, UK

Researchers in Canada and the US find that grid street layouts encourage people to walk rather than drive, unlike those dominated by cul-de-sacs, Alice Klein reports. There are more factors to consider. In the Children's Play Advisory Service report that I co-wrote – *Child's Play: Facilitating play on housing estates* – we estimate that if a housing area contains 100 children and roads that are safe enough for them to play outside, they will make around 280,000 journeys per year on foot. Not only is this free exercise, but a lot of vehicle pollution is avoided.

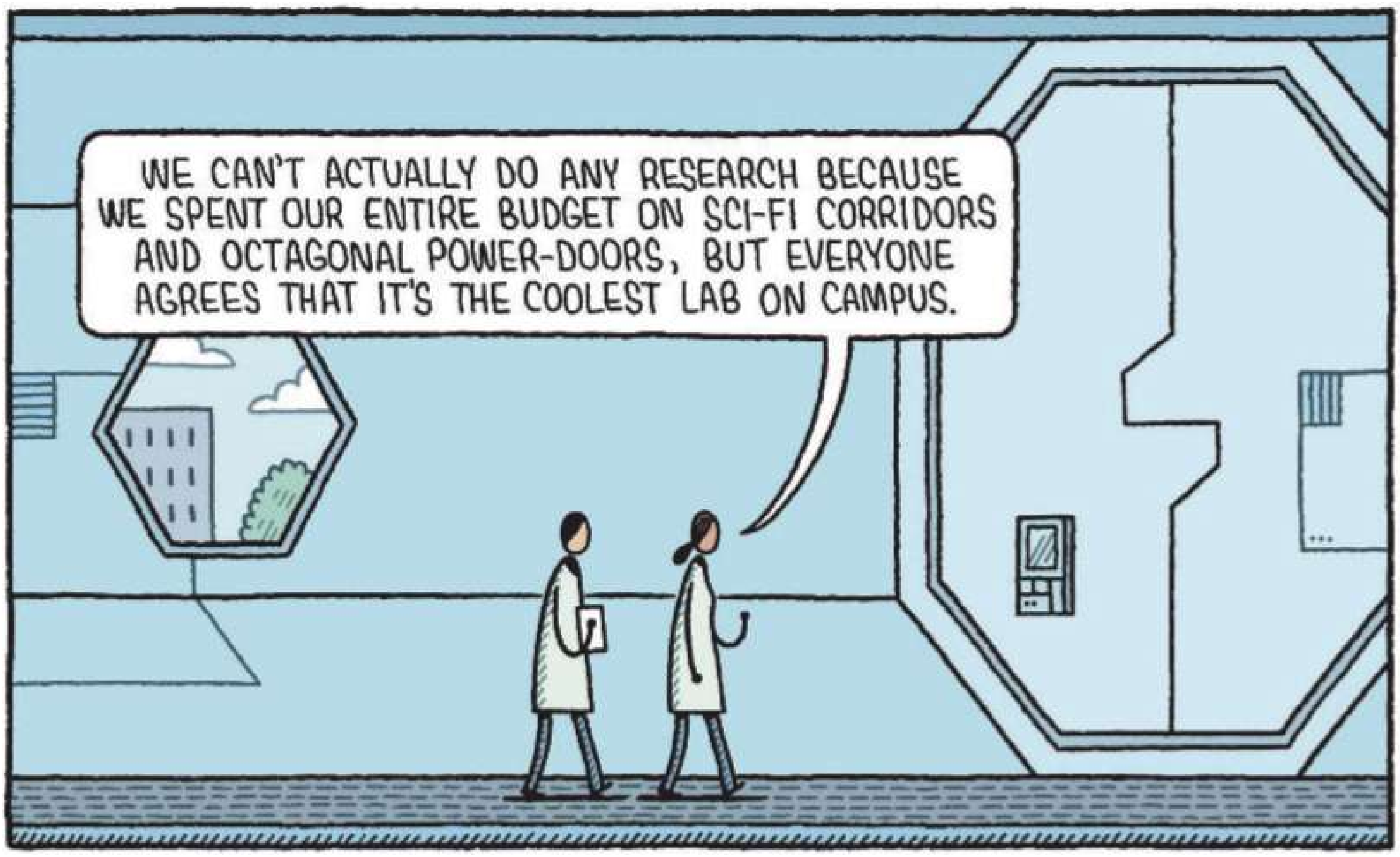
The domination of the car prevents children from playing freely, an essential part of their physical and social development. They still do play out in cul-de-sacs and where there are measures to slow traffic: parents permit this because the roads are safe. Grid layouts are more dangerous, and parents understandably keep their children indoors, condemning them to increased obesity and stress.

From Graham Jones, Bridgham, Norfolk, UK

This finding made me think of three UK towns: Colchester in Essex, where I grew up, Diss in Norfolk, where I worked for many years, and Towcester in Northamptonshire, which I visit. In all, residential areas laid out in the years after 1945 have curvy streets with cul-de-sacs.

Most of these, though, are connected by footpaths, often only 1 or 2 metres in width and ideally suited to pedestrians. So the walking route between points up to a half-hour's walk apart is very nearly a straight line, while the driving route may be as much as five times that distance. Pedestrian access to public transport is a red herring in the many places where there are now no buses.

As for cycling, the main problem in the UK is the weather. If you commute by bike, you really need a shower and clothes storage at your place of work. Planners could insist on this, in the same way as they often insist on off-street car parking for new business developments.


WE CAN'T ACTUALLY DO ANY RESEARCH BECAUSE WE SPENT OUR ENTIRE BUDGET ON SCI-FI CORRIDORS AND OCTAGONAL POWER-DOORS, BUT EVERYONE AGREES THAT IT'S THE COOLEST LAB ON CAMPUS.

TOM GAULD for NEW SCIENTIST

Some things we should learn about roundabouts

21/28 December 2019, p 65

From Robert Hale, Evesham, Worcestershire, UK

Richard Webb rightly extols the virtues of roundabouts and identifies problems implementing them in the US. There is also great scope for improvement on the way they are laid out in the UK. I do suspect that our Department of Transport may be as intransigent as the US authorities.

I am thinking of a Swiss design that allows safe, low-speed entry and exit in all traffic conditions for all vehicles, including articulated bendy buses, with high traffic flows. This is achieved by slight curves to the arms, each a single carriageway just wide enough for bus wheels. Yellow zebra pedestrian crossings on each arm remind drivers that they don't have priority under Swiss law and offer easy and safe passage for walkers and cyclists. In the UK, anyone crossing the arm of a roundabout is likely to be intimidated by speeding drivers, in part because it unnecessarily has two lanes.

All parties in the UK's recent election promised to promote cycling and walking for health and climate change advantage. That will be impossible unless we learn from the Swiss, not only on roundabouts, but more generally on road and path design.

What more can the aviation industry do?

11 January, p 18

From Butch Dalrymple Smith, La Ciotat, France

What more could the aviation industry do to reduce carbon emissions? The decision by Airbus to stop making the double-decker A380 in 2021 may need to be reviewed. This plane, particularly if configured with all seats in economy for intercontinental travel, has higher efficiency in terms of fuel used per passenger per kilometre than others.

Incorporating railway stations into more airport passenger terminals would help reverse the current trend of scheduling hundreds of flights between regional airports, which may be convenient, but is more unkind to the environment than doing a final leg by train.

A jet engine's maximum efficiency is at high throttle settings. So can we design a plane with booster engines used only for take-off, with more modest engines for cruising flight?

Running big engines for the entire flight is an absurd waste of kerosene and an abuse of the atmosphere. Clearly a new design of aircraft would be needed to stop the drag of extra engines ruining the economy gains of the concept.

Vacuum airship plan faces an uphill battle

21/28 December 2019, p 68

From Simon Goodman, Griesheim, Germany

The article on vacuum lift airships by Philip Ball was, in a manner of speaking, a gas. But some aspects of the idea sound like so much hot air. The greater lift that a vacuum gives compared to the same volume of hydrogen or helium must be greatly outweighed by the weight of the structure needed to contain that vacuum. A container evacuated of air produces lift of 1.28 kilograms per cubic metre, which is only 0.09 kg/m^3 more than hydrogen offers.

So it seems to me that this idea will not get off the ground using current materials.

More thoughts about metallic hydrogen

4 January, p 43

From David Holdsworth, Settle, North Yorkshire, UK

Michael Brooks makes the case for hydrogen existing as a metal by pointing out its position in the periodic table at the head of the group of alkali metals.

All elements in this column have a single valence, or outer shell, electron. When this is delocalised and produces electrical conductivity in an alkali metal, there are still electrons in inner shells around the nucleus. This means a stable metallic lattice can form.

Hydrogen, which has only one electron, would be left with a naked proton, so a stable lattice would be much harder to form.

We can also put this element on the other side of the periodic table, at the top of the group of non-metallic elements that require just a single electron to form a complete outer electron "shell" – the halogens.

Metallic hydrogen may be as unusual as a G-clamp with a left-hand thread, as shown in the illustration with the article.

From Clive Semmens, Ely, Cambridgeshire, UK

If metallic hydrogen were a room-temperature superconductor, experiments on it might produce useful information. But, given the enormous pressures that seem to be required to keep it metallic, it surely isn't practically useful.

A thought occurs to me: have any of the teams doing these experiments considered using pure deuterium, an isotope of hydrogen? I suspect that the pressure required to produce metallic deuterium might be significantly lower. It would pretty certainly still be much too high for practical applications, but possibly easier to experiment on.

As a community we must choose our words carefully

Leader, 14 December 2019

From Gordon Stanger, Adelaide, South Australia

I know what you mean when you write that there is no such thing as scientific truth – only successive attempts to get closer to it. So, I think, will most *New Scientist* readers. But be careful what you write. There are truth corrupters out there who will deliberately misrepresent, cherry-pick, and take words out of context.

Creationists, climate change denialists and anti-vaccination activists can, and probably will, seize upon such quotations in an attempt to discredit science and bolster their absurd claims.

Their lies cause harm. Thousands who could and should have been vaccinated against diseases such as measles have died. By 2100, multiple and complex climate change impacts will force the relocation of hundreds of millions of people – a potentially avoidable disaster.

As a scientific community we must choose our words very carefully and deter cherry-picking.

Practicalities of taking back control of our deaths

Letters, 14 December 2019

From Judy Gardner, Shrewsbury, Shropshire, UK

Bryn Glover wonders why legislation can't allow for burial of the dead on private land such as gardens. I think each local authority can permit this.

When a friend recently died in Gloucestershire, his relatives applied to their council to bury him in their garden. The council appeared flummoxed by the request. When the relatives said that their religion insisted on burial within 24 hours, the council quickly and graciously agreed it.

From Martin Pettinger, Hassocks, West Sussex, UK

It is already legal in the UK to bury loved ones in private gardens, subject to certain permissions and to regulations concerning depth, distance from buildings, and so on. Problems arise when the time comes for the survivors to move house. The emotional wrench of leaving not only a home but also a dead spouse is considerable. New buyers may not always appreciate having a body in the garden.

A burial at sea may be an option that would better suit Glover.

But the human mind/brain is deterministic

Letters, 4 January

From Greg Nuttgens, Porthcawl, Glamorgan, UK

Sam Edge mentions the common assumption that conscious entities such as human minds are self-causal and non-deterministic. Of course, like everything else in the universe, our mind/brain is deterministic, if you accept that every event has a reason or cause.

We can't mechanistically predict what someone will think about anything because of the brain's complexity – it has 86 billion neurons and a quadrillion synapses – and also because of the environmental, physical and cultural influences which affect our thinking.

If a machine could do all that, it would in effect be a human, and why would we want to create another one of them when we have 7.8 billion already?

Do students seek long-term relationships?

7 December 2019, p 15

From Jim Ryan, Cambridge, Massachusetts, US

The dating service Tinder doesn't seem to be as good at finding you a partner as you might think, according to a study that found only 25 per cent of participants reported using it to find someone interested in a long-term relationship. This sounds damning, until you read that the study subjects were all university students. It may equally be a proof that only 25 per cent of university students are looking for a long-term relationship.

I met my wife on Tinder, in my 40s. Before I met her, I went on many other dates from Tinder, all in my age range and all looking for a serious relationship. This study may say more about our reliance on students as study subjects than about anything else.

When a game solves an impossible problem

14 December 2019, p 32

From Paul Whiteley, Bittaford, Devon, UK

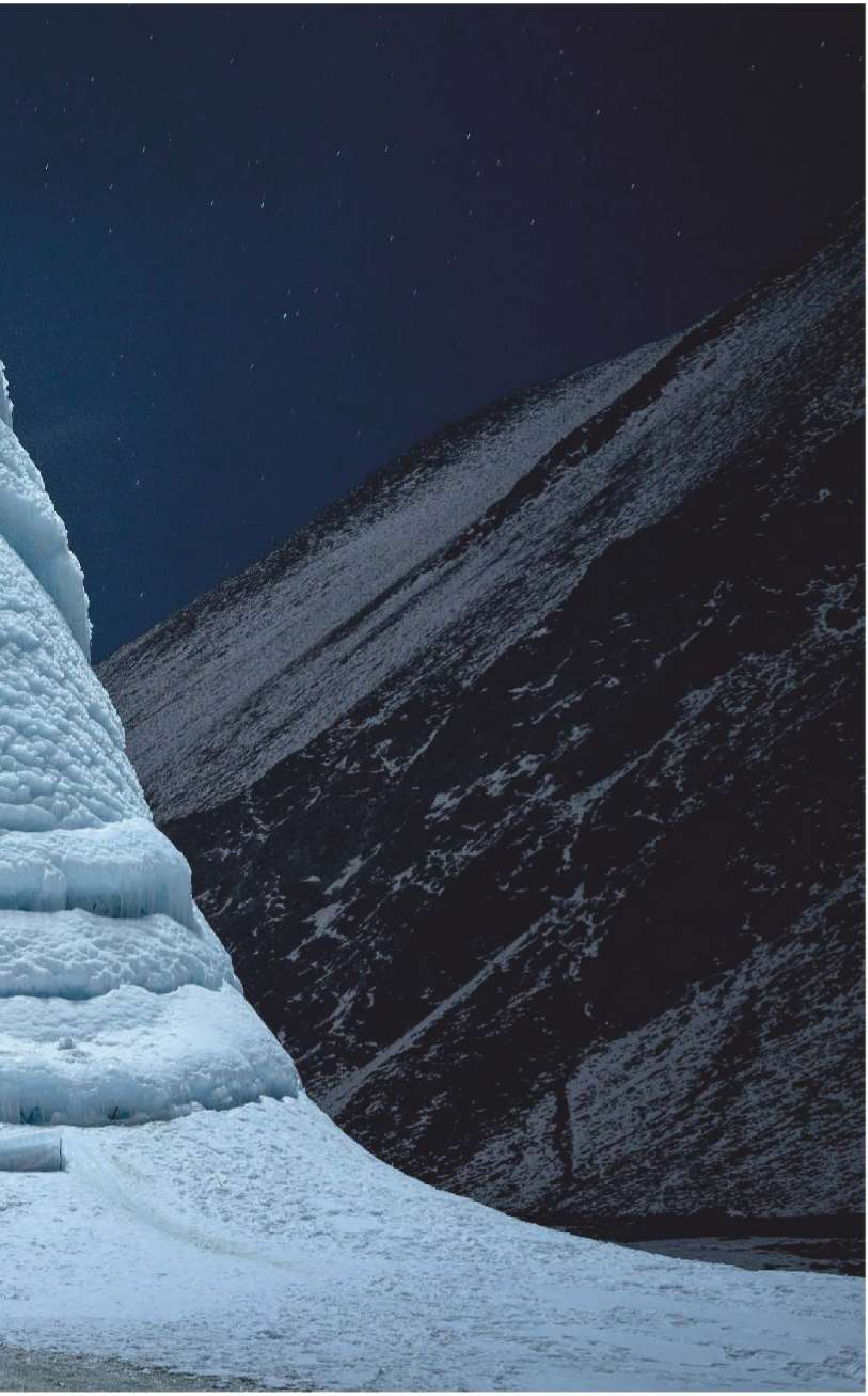
Jacob Aron has been playing the game *Death Stranding*, in which you must carefully choose your route or die. Has he unwittingly been drawn into a vast data accumulation programme that an artificial intelligence can eventually use as a data set for solving the currently intractable travelling salesman problem?

For the record

- **We misnamed a dog breed on our chart showing their sizes and life expectancies: it is a Bernese Mountain dog (4 January, p 38).**
- **It is the nerves within the clitoris that are rarely depicted or described in textbooks (4 January, p 12).**

Want to get in touch?

Send letters to New Scientist, 25 Bedford Street, London WC2E 9ES or letters@newscientist.com; see terms at newscientist.com/letters



Icy invention

Photographer **Greg White**

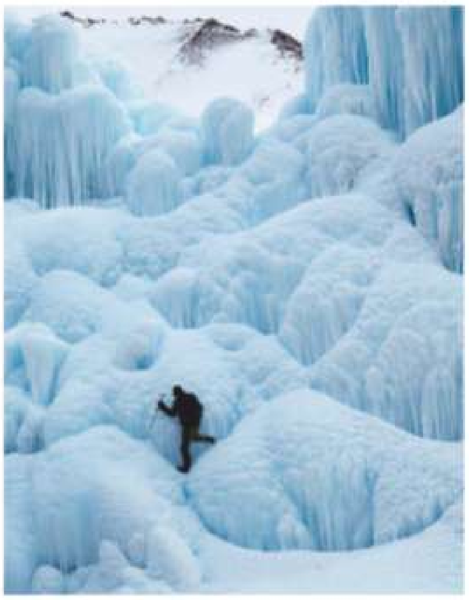
THE Himalayan desert of Ladakh is home to this majestic tower of ice, known as an ice stupa, after the domed Buddhist buildings. It is effectively an artificial glacier, created by local people to store water and designed to start melting when they need it.

In winter, temperatures in Ladakh rarely rise much above -40°C, and can fall below freezing even on summer nights. The area receives little rain, so local people rely on melting glaciers to obtain water for irrigation and livestock.

But climate change has caused the glaciers to shrink and the flow of their meltwater to become erratic. To get around this, in late summer, local people catch glacial meltwater in underground pipes. The water is sprayed onto a domed structure at night, where it freezes.

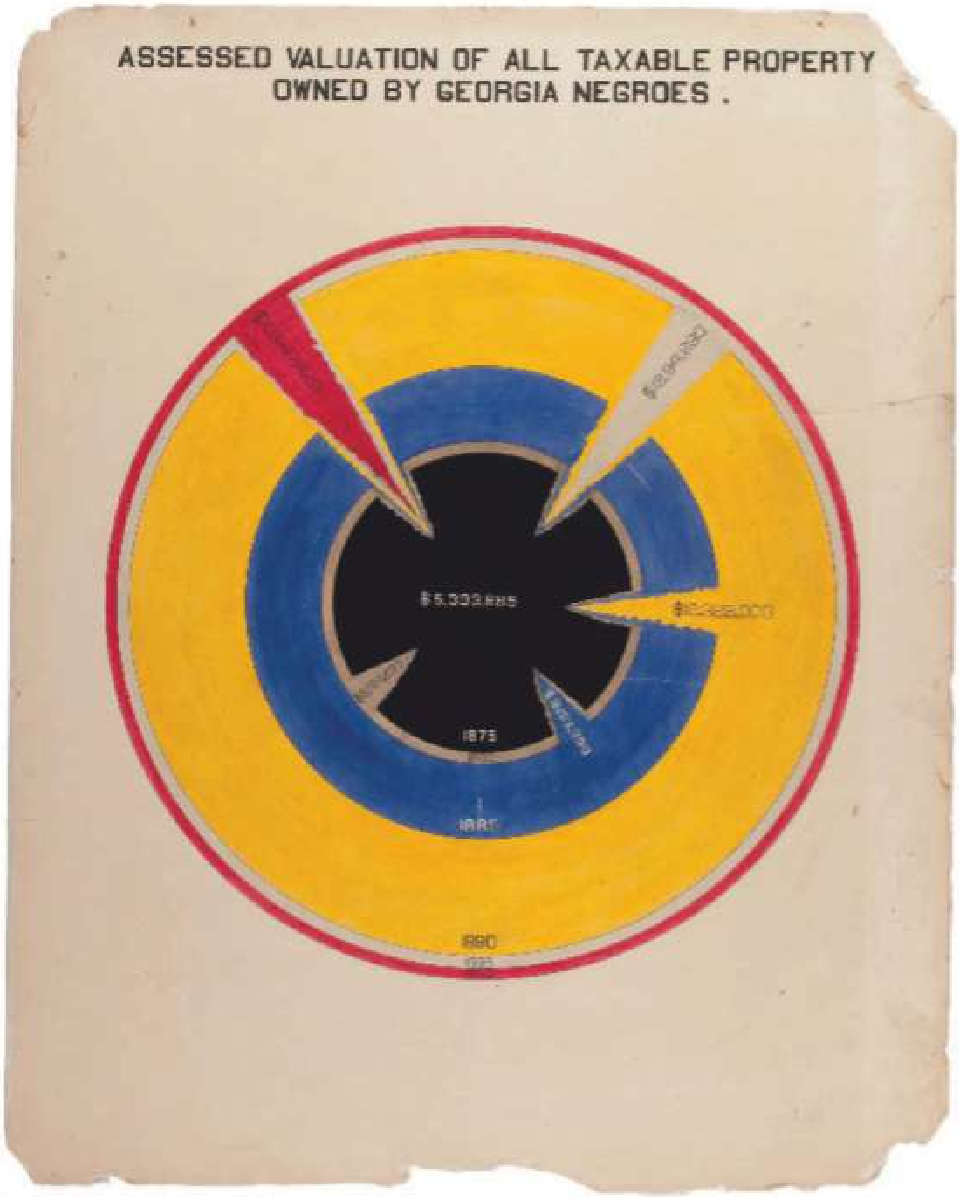
The ice stupa starts to melt in March and will continue to do so until around July, when rainfall is at its lowest. Its conical shape shields much of the ice from the sun. This means the tower, which can reach 50 metres in height (see below), melts slowly, feeding surrounding streams. The following summer, the cycle repeats. ▮

Jason Arunn Murugesu



Black data matters

Civil rights go hand in hand with access to information technology, says **Lilian Anekwe**



© WEB DU BOIS/LIBRARY OF CONGRESS

Book

Black Software: The internet and racial justice, from the AfroNet to Black Lives Matter
Charlton D. McIlwain
Oxford University Press

Exhibition

W. E. B. Du Bois: Charting black lives
House of Illustration, London
Until 1 March

DECADES before the creation of social media and the birth of the #BlackLivesMatter movement, early adopters of the internet were using precursors of email, user forums and the web to organise black communities in the US and beyond and push for racial justice.

In his book *Black Software*, Charlton D. McIlwain at New York University highlights the lives and histories of those pioneers who explored and used the internet for digital activism, creating a space for the African American community.

McIlwain has made excellent use of his position as the founder of New York University's centre for critical race and digital studies. In the book, he combines first-person interviews with historical online and offline correspondence and other archive materials to bring the stories and perspectives of these forgotten figures to light.

Over five decades, beginning in the 1960s with the rise of the civil rights movement in the US and the start of the computing revolution, McIlwain traces a path from this "vanguard" to present-day activists, campaigners and organisers.

In the first half of the book we learn how black entrepreneurs, engineers, information technicians, hobbyists, journalists and activists connected with each other, using new technologies as they emerged: bulletin board systems and the Usenet network in the 1970s, file-sharing and CD-ROMs in the 1980s.

The Universal Black Pages, a comprehensive online directory of African American-related internet resources, was launched in July 1994. McIlwain describes its rise and fall, along with websites such as NetNoir and AfroNet. This was an experimental era, which ultimately fell victim to the dotcom bust in 2000.

In the second half of the book, McIlwain delves deeper, back to the origins of the computing revolution, showing how the technology was put to use to "set America's principles of white supremacy loose to run amuck in new computational systems".

This culminated, McIlwain argues, in the development of law enforcement applications that applied computing power to areas such as crime analysis, fingerprint identification and resource allocation. We think of the use of algorithms by police forces as a new phenomenon; McIlwain describes how these technologies were in use by police forces as early as the mid-1960s.

These information systems and connected databases later developed into automated policing systems and crime prediction tools which "began to lock black people up at skyrocketing and racially disparate rates".

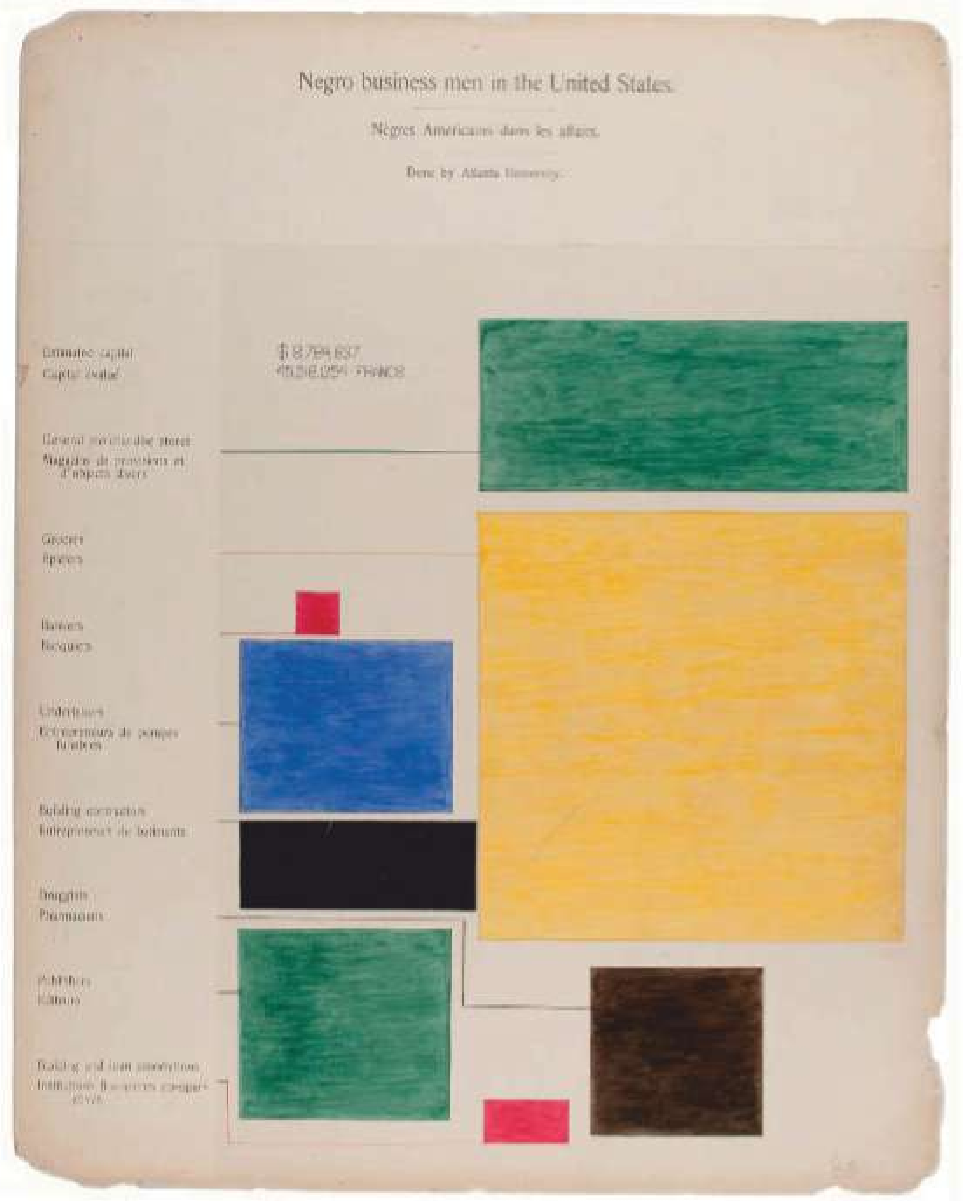
This was only possible, McIlwain argues, because black people, "by and large, didn't have access to the technology being used to profile, target, and forecast their tendency toward criminality". The early computing industry's lack of diversity and resistance to attempts at inclusion meant that black people were effectively excluded from conversations about, and deprived of access to, the very technology that would go on to shape their lives.

> **"We think police algorithms are new; but these technologies were in use by the mid-1960s"**

"Black people were not hired as technicians to process the data. Black people certainly did not design the systems... were not at the table to contribute to conversations about how to deploy the outputs," he writes.

It may have started as "an alien technology destined to... grind them into submission and exert racial power over their entire existence", but change was ushered in, as members of the African American tech vanguard encouraged others to get online, harnessing the power of the internet to shape their lives.

McIlwain quotes one activist: "We... who were ignored by the industrial revolution, cannot afford to be bypassed by the multimedia communications revolution inherent in the



Du Bois visualised his community in a compact and systematic form

emerging information superhighway… to avoid our continuing characterisation, lamented by [W. E. B.] Du Bois, as an 'afterthought of modernity'."

That mention of Du Bois is apposite: this influential African American activist and intellectual had started a movement in the early 1900s to fight racial segregation. Just as the members of McIlwain's vanguard are little known despite their innovative use of communications technology, so Du Bois's use of infographics tends to be omitted from accounts of his work to end segregation.

As co-founder of the National Association for the Advancement of Colored People (NAACP), Du Bois is celebrated for his profound essays and books, including the seminal *The Souls of Black Folk*, and is considered one of the most influential activists for racial justice of the 20th century.

But alongside his famous writings, Du Bois produced an astounding body of infographics to challenge pseudoscientific racism, making visual arguments every bit as powerful as those in his books. The infographics are the subject of an exhibition, W. E. B. Du Bois: Charting black lives, at London's House of Illustration. This displays, for the first time in the UK, 63 infographics that Du Bois presented at the 1900 Paris Exposition, a world fair.

Du Bois's charts, graphs and maps, the result of collaboration with African American students he taught at his sociology lab at Atlanta University in Georgia, are beautiful. Visually, they are certainly striking. And then there is what they represent: a radical and stark approach to refuting racism, using facts and statistics to counter white supremacy and challenge and debunk the era's prevailing racist stereotypes.

Du Bois wanted to prove, to an international audience, the essential equality of African American people. By presenting his own research on the achievements of African Americans in the short time since the emancipation of slaves, Du Bois demonstrated that black culture had flourished even within the extreme constraints of violently enforced racial segregation across the southern states of the US.

> **"Du Bois produced infographics that challenged the pseudoscience used by racists"**

The infographics shown at the Paris Exposition presented statistics on issues such as crime, literacy and affluence in Georgia – at the time the US state with the highest African American population. And rather than let us fall into the complacency of thinking that race science no longer exists, the exhibition also features original artwork by *Guardian* journalist Mona Chalabi. This demonstrates the enduring relevance of Du Bois's data visualisation methods and the racial inequalities he fought against by updating four of the 1900 infographics with 21st-century data.

Both the exhibition and McIlwain's book are utterly compelling demonstrations of the contributions black people have made, and struggle to make still, to modern culture.

The work Du Bois began in 1900 with his data visualisations has lasted into the internet age, and the web has become a key venue for conversations about why black lives matter. ▮

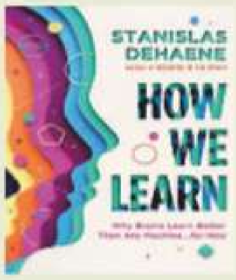
Don't miss

Visit

Making the Bridge Sing sees the Victorian Engine Rooms of London's Tower Bridge fill with music from 29 January, as artist Di Mainstone documents her efforts to turn the structure into a musical instrument.

Visit

Claudia Andujar, The Yanomami Struggle is a record of Andujar's attempts to save what little she could of the Amazon's Yanomami culture. This poignant photo exhibition is at the Fondation Cartier in Paris from 30 January.



Read

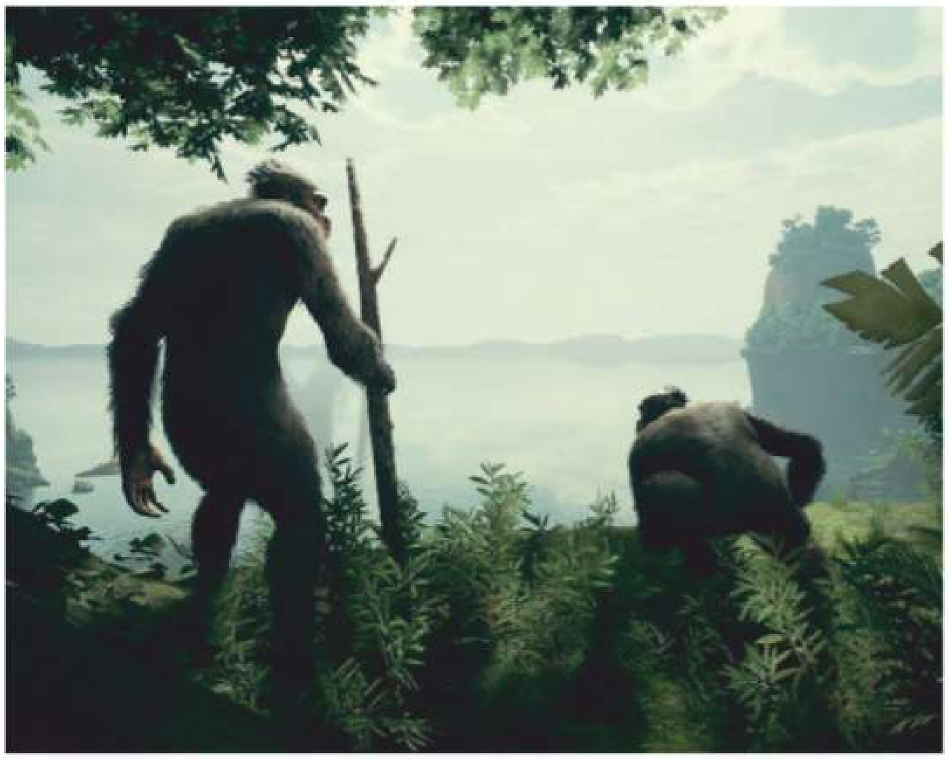
How We Learn (Allen Lane) argues that the brain isn't a computer, and is far more capable of handling the world. Neuroscientist Stanislas Dehaene reveals the brain's strange secrets, and how machines can copy them.

TOP: © DI MAINSTONE/TOWER BRIDGE; MIDDLE: ©CLAUDIA ANDUJAR/FONDATION CARTIER POUR L'ART CONTEMPORAIN

The games column

An odyssey too far Games are great if you want to leapfrog a building, grow to a giant size or outpace a bullet. But their superpowers evaporate when tackling the epic story of evolution, finds **Jacob Aron**

Jacob Aron is *New Scientist*'s deputy news editor. He has been playing video games for 25 years, but still isn't very good at them. Follow him on Twitter @jjaron



PANACHE DIGITAL GAMES

Enjoy it while it lasts: the primate protagonists of *Ancestors* try not to die

AN APE-LIKE creature examines the skeleton of a warthog. As horns swell and drums beat, the animal picks up one of the bones and begins crashing it around. Then it raises a fist to the sky and slams the bone into the warthog's skull, smashing it to pieces.

This iconic and spine-tingling scene from the film *2001: A Space Odyssey* is an attempt by director Stanley Kubrick to distil the moment our distant ancestors took their first step to becoming modern humans. The game *Ancestors: The humankind odyssey* attempts to go one further and depict millions of years of human evolutionary history – but it falls flat.

You can't fault lead designer Patrice Désilets for his ambition. He helped create *Assassin's Creed* and its sequels, which put players in historical settings from ancient Greece to Renaissance Italy. "I went, let's do the very beginnings of it all, the beginning of the odyssey. Not 10,000 BC, let's go 10 million years ago," he says.

The game opens with an ape-like creature carrying her child on her back, ambling through a jungle in Africa, before being suddenly killed by a giant bird. You take control of the child and find a safe place to hide, and then the game shifts to put you in control of another ape, who must now attempt to find the lost infant.

My odyssey didn't start well. Within a few minutes, my ape had been eaten by a crocodile, and I flashed into the body of another creature from the tribe, only to be poisoned by a snake bite, attacked by a warthog and flee in fear.

"My most satisfying experience was learning how to retrieve honey. Then the bees attacked"

The experience is baffling, by design, as the game explains very little. Just as our ancestors had to figure out everything for themselves, so do players of *Ancestors*. You can use the ape's senses of smell and hearing to search the environment, and interact with all manner of plants and objects in an attempt to find a use for them. Désilets says they studied the latest science to inform what went into the game.

My most satisfying experience while playing was when I realised I could take a stick, strip the leaves, then use it to poke a beehive and retrieve honey. Then the bees attacked and I nearly died again.

The game progresses as you complete new actions with a child in tow, generating "neuronal energy" that you can use to evolve new skills. You can then choose to advance a generation, locking in some of those skills, and eventually evolve, passing hundreds of thousands of years in the blink of an eye.

It is an interesting view of evolution, but rather Lamarckian: the idea that animals can gain new traits during their lifetime that can be passed on biologically. This view has been widely discredited, as it goes against the accepted theory that what we pass on are the genes we are born with.

The trouble is, the game is quite dull. After you evolve, you find yourself in the same jungle location – others, such as a savannah, are available, but I never made it that far into the game. I just kept doing the same things, hoping I wouldn't randomly die.

Other attempts to capture evolution in a game, such as the galaxy-spanning *Spore* or quirky platformer *E.V.O.: Search for Eden*, have also flopped. Maybe when it comes to compressing millions of years into a single experience, only Kubrick's dramatic genius will do. *Ancestors* felt more like an infinite supply of monkey gamers hammering relentlessly at a genetic keyboard. ■

Game

Ancestors: The humankind odyssey

Panache Digital Games

PC, PlayStation 4 and Xbox One

Jacob also recommends...

Book

Evolution

Stephen Baxter

Gollancz

The best fictional treatment of evolution I've read, because it gets across the absolute horror of what millions of years of genetic mutations will do to our species. Baxter's elephant-like post-humans roaming the ruins of modern civilisation haunt me still.

Land of fire and ice

Majestic landscapes, erupting geysers, hot springs and bubbling mud

Departing:
31 October 2020, 7 November 2020
8 days for £2,249 (approx $2,855)

Iceland is one of the world's most intriguing destinations for science enthusiasts. Accompanied by leading academic volcanologist Tamsin Mather, you will go on an eight-day volcanic and geological adventure around this fascinating island.

Unforgettable experiences on this tour include:

- **A chance to see the aurora borealis during the evenings.**
- **Visit geological wonder Þingvellir National Park.**
- **A trip to the elegant Seljalandsfoss waterfall where you can walk behind the plummeting torrent.**
- **Superjeep safari tour of Hvolsvöllur.**
- **A walk on Europe's biggest ice cap, Vatnajökull.**
- **Swim in the geothermal waters of the Secret Lagoon.**
- **Investigate Reykjanes Peninsula to see where two tectonic plates meet.**

Due to high demand we have two departure dates on this tour with only 15 places available per tour. We expect places to be booked quickly, so get in touch early to secure yours.

To book call +44 203 308 9917 (UK office: Mon-Sun 9am to 5.30pm GMT)
Or email groupsuk@intrepidtravel.com

newscientist.com/tours

In partnership with Intrepid Travel

ABTA No.Y0766

Rethinking mental health

Growing evidence that many mental health conditions share an underlying cause could transform their treatment, finds **Dan Jones**

LIFE can be tough. All of us have experienced nagging worries, anxiety, sadness, low mood and paranoid thoughts. Most of the time this is short-lived. But when it persists or worsens, our lives can quickly unravel.

Mental health conditions, including everything from depression and phobias to anorexia and schizophrenia, are shockingly common. In the UK, one in four people experience them each year, so it is likely that you, or someone you know, has sought help from a professional. That process usually begins with a diagnosis – a mental health professional evaluates your symptoms and determines which of the hundreds of conditions listed in psychiatry's classification bible, the *Diagnostic and Statistical Manual of Mental Disorders*, best fits. Then you start on a treatment tailored to your condition. It seems an obvious approach, but is it the right one? "For millennia, we've put all these psychiatric conditions in separate corners," says neuroscientist Anke Hammerschlag at Vrije University Amsterdam, the Netherlands. "But maybe that's not how it works biologically."

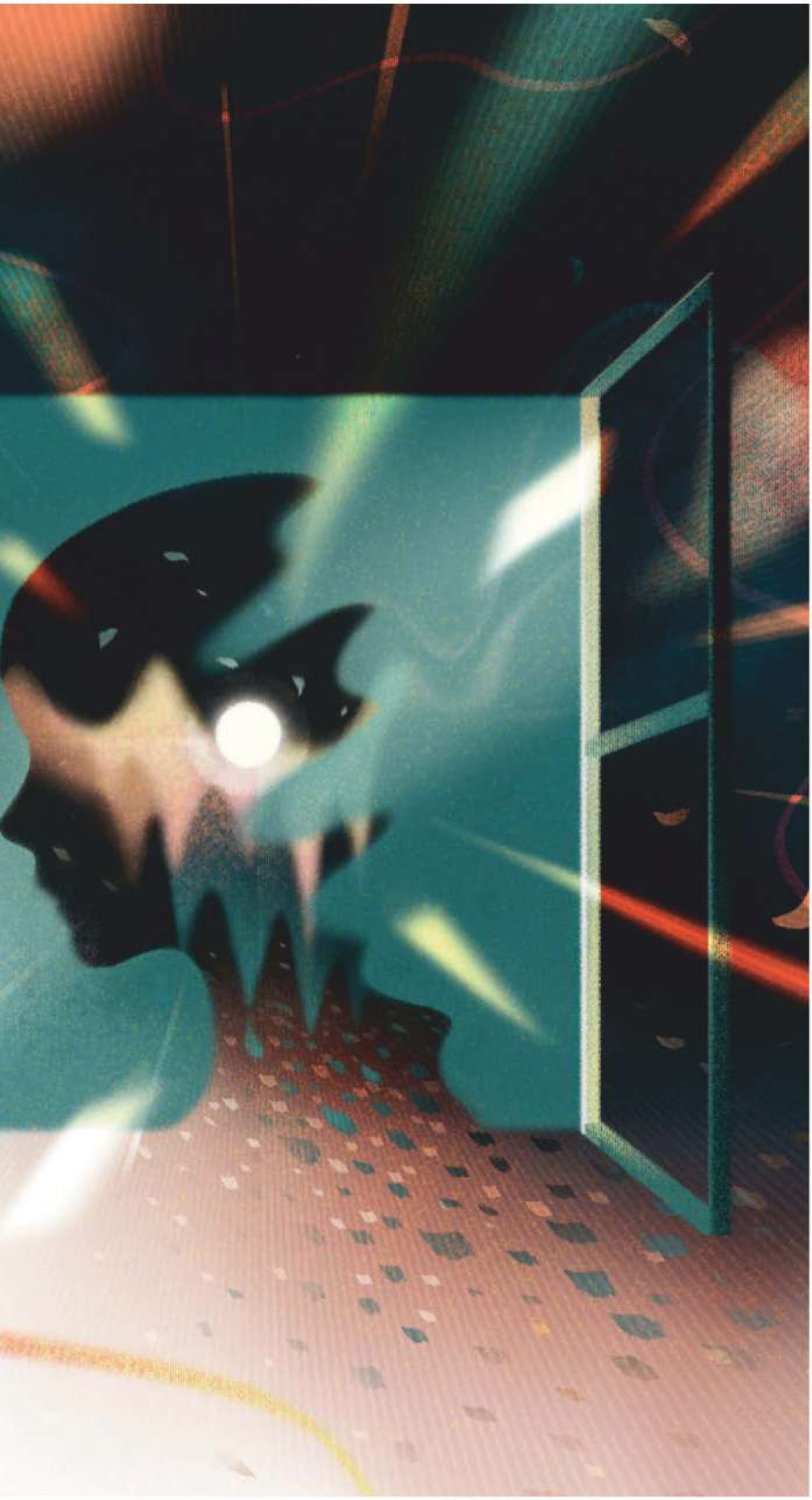
There is growing and compelling evidence that she is correct. Instead of being separate conditions, many mental health problems appear to share an underlying cause, something researchers now call the "p factor". This realisation could radically change how we diagnose and treat mental health conditions, putting more focus on symptoms instead of labels and offering more general treatments. It also explains puzzling patterns in the occurrence of these conditions in individuals and families. Rethinking mental health this way could be revolutionary: "I don't think there are such things as [discrete] mental disorders," says behavioural geneticist Robert Plomin at King's College London. "They're just fictions we create because of the medical model."

At first glance, the idea that different mental health conditions with distinct symptoms share an underlying cause seems counter-intuitive. The key to understanding it lies in its name. "P factor" has intentional parallels with one of the most famous concepts in psychology. More than a century ago, British psychologist Charles Spearman noted that children's performance on one kind of mental task, say verbal fluency, was correlated with their mental skill in other areas, like mathematical reasoning, spatial manipulation and logic. In other words, children who are good at one thing tend to be good at another, while those who struggle in one area tend to struggle in others. Using a statistical tool called factor analysis, Spearman showed that this is because these different mental abilities are all linked to an overarching cognitive capacity, which he named general intelligence, or the g factor.

A century on, applying the same approach to mental health diagnoses provided the first hints that something similar might be going on. There are a wide range of mental health conditions that manifest with different behavioural and psychological symptoms. Like cognitive skills, they cluster together in

JASU HU

Sign up for our new health newsletter!
All the essential wellbeing news you need delivered to your inbox every week **newscientist.com/sign-up/health**



individuals, either at the same time or one after another. In 2012, Benjamin Lahey at the University of Chicago and his colleagues analysed information on such diagnoses among 30,000 people studied over three years. Using factor analysis, they found that the observed patterns of illness were best explained by a general tendency towards mental health conditions.

The following year, Avshalom Caspi and Terrie Moffitt at King's College London got the same result. Their study used information from 1000 people whose health had been tracked for four decades since their birth in the early 1970s. It was Moffitt and Caspi who coined the term p factor to describe an individual's broad susceptibility to mental health problems. "Once you have any given mental disorder, it increases the likelihood that you'll have multiple other kinds of disorders," says Caspi.

Puzzling heritability

The p factor can also explain puzzling patterns of mental health conditions within families. It had long been known that these conditions have a genetic basis, and are highly heritable. Huge twin studies have estimated the heritability of schizophrenia, for example, at nearly 80 per cent, and major depression at about 45 per cent. But having a parent or sibling diagnosed with a given condition doesn't just increase the odds that you will experience it. It also increases the likelihood that you will be diagnosed with a different condition. For instance, if a parent has schizophrenia, your risk of developing bipolar disorder doubles, and vice versa. That makes sense if you inherit not just a risk for one kind of condition, but a more generalised risk: the p factor.

Indeed, the application of genetics to psychiatry in the past decade has provided key support for the existence of the p factor. In the early days, psychiatric genetics mostly entailed a hunt for individual genes conferring significant risk for developing certain conditions. But this so-called candidate gene approach hit the skids. "It was really a dead loss, but it was all we could do at the time," says Plomin. "Then SNP chips came along in the mid-2000s and changed everything."

SNP (pronounced "snip") chips, which look a bit like the memory card in a digital camera, allow scientists to use a small DNA sample to scan someone's genome and discover which genetic variants they carry. Everyone has millions of single-letter differences in DNA's › four-letter code: where one person has a T, for example, another might have a G (and someone else could have A or C). More than 10 million of these single-nucleotide polymorphisms (SNPs) have been identified, and a single SNP chip can detect a million or more of them in one go.

The breakthrough for the p factor idea came a few years before Moffitt and Caspi coined the term. In 2009, the International Schizophrenia Consortium used SNP chips to genetically analyse more than 3000 people diagnosed with the condition. Instead of pulling out one or a few genetic variants with big impacts on schizophrenia susceptibility, the analysis found the condition was linked to thousands of variants, each having a small effect. Intriguingly, these same variants also increased the risk of bipolar disorder.

Shared genes

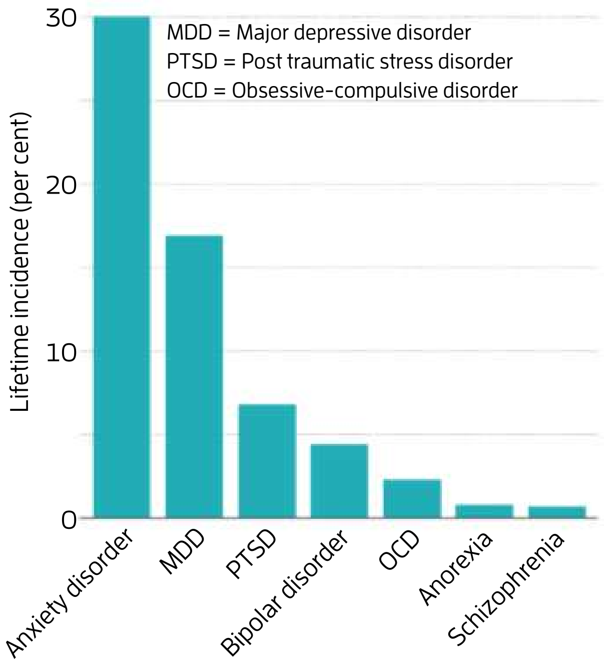
Later, this kind of analysis was extended. In 2013, an international group called the Psychiatric Genomics Consortium completed a landmark study. Scientists analysed genomic data from more than 30,000 people diagnosed with conditions including bipolar disorder, major depression or schizophrenia. Again, genetic risk variants cut across the traditional diagnostic boundaries of psychiatry. “It’s the opposite of what was expected,” says Mike Gandal at the University of California, Los Angeles. “Until recently, it was thought that genetic studies would reveal more biological specificity for each disorder, but instead we’re seeing all this shared genetics.”

Tellingly, the story is very different for neurological conditions, which affect the nervous system itself, such as Alzheimer’s, Parkinson’s, Huntington’s and multiple sclerosis. A 2018 study from the Brainstorm Consortium based at Harvard University examined genetic data from more than 265,000 people with one of 25 psychiatric and neurological conditions. This revealed that neurological conditions have little or nothing genetically in common with each other or with psychiatric conditions, making them a much better fit for the classical medical model.

For neurological conditions in which single genes play a big role, people can be divided into two groups: those who carry the risk variant and those who don’t. The picture is much messier for mental health conditions. The thousands of SNPs underlying them follow a bell-shaped distribution, meaning that a small percentage of people have very few risk variants, a small percentage have a lot, and most people fall somewhere in between, with symptom severity roughly tracking this curve. “There’s no break point at which the number of variants suddenly leads to a diagnosable psychiatric disorder,” says Plomin.

How common are mental health conditions?

Around a quarter of people in the UK experience mental health problems each year, with anxiety and depression being by far the most prevalent diagnoses



SOURCES: CDC, HARVARD MEDICAL SCHOOL doi.org/gd4b88, doi.org/dzvqfw

It gets messier. Researchers are now discovering some SNPs associated with individual conditions. “There’s this huge genetic overlap between psychiatric disorders, but there are also some specific genetic factors that make people differ in their symptoms,” says Christel Middeldorp, who studies psychiatric genetics at the University of Queensland, Australia. “The p factor doesn’t explain everything.”

In addition, as Caspi is quick to stress, there is more to the story than genes. “The genetic work is exciting, but what’s really remarkable about most psychiatric disorders is that they share the same environmental and psychosocial risk factors as well,” he says. “Child abuse of any kind, for example, predicts every condition under the sun.” The same is true for drug and alcohol abuse, and traumatic experiences during childhood such as being displaced by warfare.

> **“There’s a huge genetic overlap between mental health conditions”**

Plomin and his colleagues recently attempted to quantify the genetic component of the p factor. Drawing on information from more than 7000 pairs of twins, they estimated its heritability at around 55 per cent. This means that genetic differences explain just over half of the variation between people’s general susceptibility to mental health problems, with the rest being driven by non-genetic factors. The study also showed that the p factor is stable across a person’s lifetime.

Despite these complications, there is growing recognition that mental health conditions have a shared genetic basis, and the search is on to find out how this manifests biologically. In 2018, Gandal and his colleague Dan Geschwind led a team to do just that. They analysed gene expression in the cerebral cortex – the brain’s outer layer where higher cognition occurs – from 700 post-mortems of people diagnosed with mental health conditions. “We found that disorders that share the most genetic risk factors, like schizophrenia and bipolar disorder, look very similar in the gene-expression patterns as well,” says Gandal. Many of the genes involved controlled activity at synapses, the junctions between neurons.

A recent study led by Hammerschlag backs this up. Her team investigated more than 7000 sets of genes involved in a wide range of biological pathways, and then looked at which contained genes with variants linked to five common mental health conditions. Only 14 fit the bill. “Almost all of these gene sets have a function in neurons, and most play a role in the synapse,” she says. In other words, the p factor seems to have something to do with communication between brain cells.

The latest research is even more enlightening. Maxime Taquet at the University of Oxford and his colleagues believe they have identified a “vulnerability network” in the brains of children at high genetic risk of developing mental health conditions. Comparing their brain scans with those of children with a low genetic susceptibility, the team found large differences in three key areas: a structure called the default network that is active while the brain is at rest, a second structure involved in planning and control, and the part of the brain that processes vision. In a similar study, Caspi and Moffitt found that people with a higher p factor have differences in a brain

Talk-based therapies are used to treat a variety of mental health conditions

SOLSTOCK/GETTY IMAGES

circuit crucial for monitoring and processing information so it can be used in higher cortical functions such as regulating emotions, thoughts and behaviours.

It is still something of a mystery how having a brain with these sorts of features might influence an individual's psychology. Caspi and Moffitt think that a high p factor probably manifests as a combination of disordered thinking, difficulties regulating emotions and a tendency towards negative feelings. However, even if these links aren't yet clear, the p factor idea may be useful for diagnosing and treating mental health conditions.

Already, many drugs are known to be beneficial in supposedly distinct diagnoses. "In practice, we often use the same treatment for different disorders," says psychiatrist Tova Fuller at the University of California, San Francisco. "Antipsychotics, for example, are useful not only in psychosis, but also in mania, delirium, agitation and other conditions." The p factor makes sense of these "transdiagnostic" therapies. Yet they weren't developed with it in mind. "If we can figure out the biology of the p factor, then it might be possible to target the mechanisms involved and develop therapies that work better across disorders," says Gandal. "These could be given to a large number of patients, rather than treating each person based on their specific pattern of symptoms."

Talk-based treatments, such as cognitive behavioural therapy (CBT), also have transdiagnostic value. "There are always lessons for the patient on how to reframe stressful experiences and look on the bright side, how to identify triggers that set off their symptoms, and guidance on life skills," says Moffitt. Currently, there are separate therapeutic guidelines for specific conditions. However, the p factor idea lends support to clinicians advocating a one-size-fits-all version of CBT called the common elements treatment approach in an attempt to ensure that more people globally get the treatment they need.

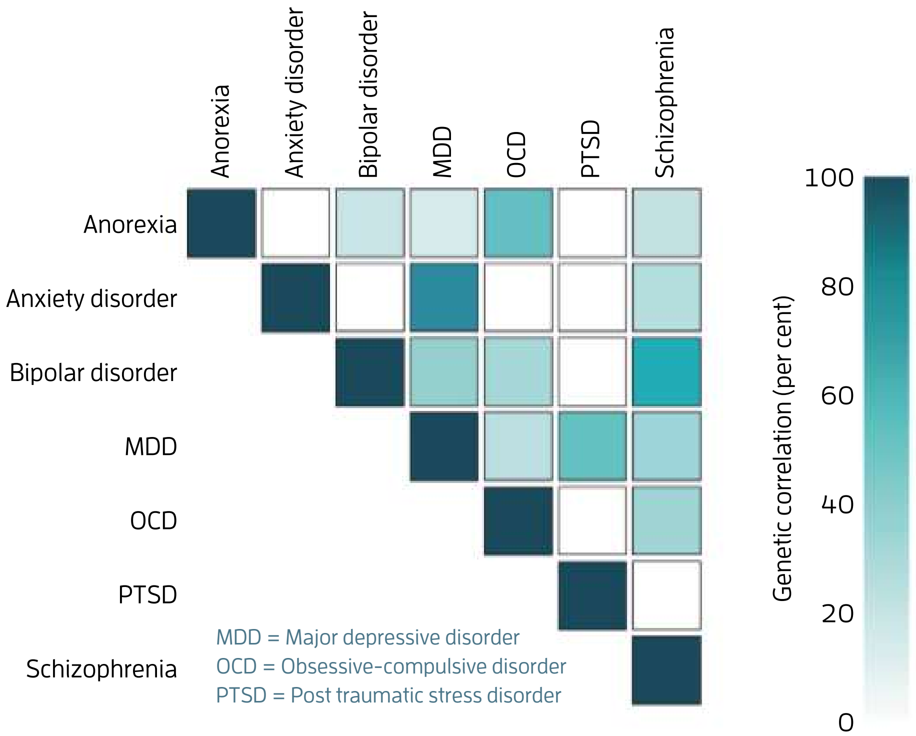
"It's a front-line cognitive therapy that can be offered to everybody who has mental distress," says Moffitt. "Then, after that, people could be referred onwards to a specialist who treats, say, only schizophrenia or panic attacks, depending on the symptoms present."

Moffitt also believes that the existence of the p factor should prompt a shift from treating conditions themselves to treating the often distressing symptoms people experience. "We tend to think: 'This person has depression today, so this is a person who is depressive and we really need to focus on depression'," she says. "We obviously need to treat their depressive symptoms, but, knowing that this patient will present with different symptoms in the future, we also need to provide them with tools and skills to cope when they arise."

Plomin goes even further. For him, the blurred biological lines between mental health conditions alongside the genetic continuity of susceptibility across populations demolish the orthodox view of mental illness. "I think these diagnostic classifications are mostly a myth," he says. That doesn't mean people don't experience mental health problems that require the help of a professional, but Plomin would be happy to see the current model of psychiatry go the way of the dodo. "It's caused a lot of harm because it implies there are mentally ill people versus 'normals'," he says. "Really we're all somewhere along a continuum." ▮

Mental health conditions are not so distinct

Psychiatric conditions have many genes in common, supporting the idea that there is an underling cause that makes individuals more or less susceptible to them



MDD = Major depressive disorder
OCD = Obsessive-compulsive disorder
PTSD = Post traumatic stress disorder

SOURCE: doi.org/gdrmcg

Dan Jones is a freelance science journalist based in Brighton, UK

LYNN GAIL/GETTY IMAGES

Finding Sahul

How did Stone Age people reach the far-flung continent that contained Australia? It was no accident, discovers **Graham Lawton**

FOOTPRINTS in the sand marked the beginning of the end of an epic journey. They were left fleetingly on a mangrove-fringed beach in south-eastern Asia some 65,000 years ago, when a group of humans lashed together a bamboo raft in the hope that it would carry them over the horizon.

They eventually washed up on the shores of Sahul, a lost continent made up of Australia, New Guinea, Tasmania and a lot of what is now seabed. This was the final destination of the out-of-Africa dispersal that had already peopled much of southern Eurasia. But it wasn't just another stepping stone. Sahul was far offshore, requiring a voyage of many days across a chain of islands separated by deep, open sea, sometimes with little sight of land.

Exactly how these ancient people did it remains a mystery. The waters around the island groups they would have navigated are treacherous, and it has long been assumed that early humans didn't have the necessary tools, mental or maritime. "It's the equivalent of sending a spaceship to the moon," says Michael Westaway at the University of Queensland in Australia. "There's nothing comparable in human evolution at that time."

Until recently, scholars tended to think that the crossing was accidental. But new evidence suggests more strongly than ever that it was planned, perhaps involving thousands of people, many rafts and great seafaring skill. If we get a better idea of the likely route taken, it will allow archaeologists to take their own leap of faith and seek fresh clues to find out how it was done, perhaps solving one of the great puzzles of the human conquest of the world.

When Sahul was colonised, the geography of what is now South-East Asia and Australasia was quite different to how it is today. The world was in the grip of an ice age with huge amounts of water locked away in ice caps and glaciers, so the sea level was up to 85 metres lower. What is now the bottom of the Gulf of Carpentaria off northern Australia was dry land; the submerged Sahul Banks in the Timor Sea off Western Australia were coastline.

Distances were different too. These days, the journey from the southernmost tip of Asia to Australia is 463 kilometres. Back then it was just 90 kilometres. But even that is a long voyage, especially for people with only the most basic kit.

Roughly 60,000 years is about as far back as you can go before our ancestors stop being fully human. It is about the time they became "behaviourally modern", possessing language, symbolic behaviour, abstract thinking and creativity. But technologically and socially, they were still firmly in the middle Stone Age: nomadic hunter-gatherers with flint tools but no pottery, metal, agriculture, axes, wheels or domestic animals.

That goes a long way to explaining why, until recently, the prevailing view was that the sea crossings between Asia and Sahul presented such an obstacle that deliberate migration was unthinkable. People must have arrived on the currents after being washed into the sea by a tsunami or flood, perhaps clinging to a mat of floating vegetation or a raft of pumice.

This so-called "sweepstake colonisation" is often invoked to explain how terrestrial reptiles and mammals make it onto distant tropical islands, and it could plausibly account for the peopling of Sahul. Prevailing ocean currents are favourable and any floating castaways caught in them would have found the vast Sahul "hard to miss", according to archaeologist Jane Balme at the University of Western Australia in Perth.

Rocky Point in Arnhem Land, Australia, was part of the interior when the first humans arrived

However, such scenarios are increasingly seen as unlikely – for two main reasons. Archaic humans, notably *Homo erectus*, were present in south-eastern Asia for the million years before people turned up in Sahul, but there is no evidence of them ever reaching the continent during that time. The same goes for the region's other large-bodied mammals. The other reason is demographic: even if people were accidentally swept alive to Sahul, they were vanishingly unlikely to have arrived in sufficient numbers to start a viable colony.

Admittedly, deliberate colonisation also seems implausible. "Nobody has put the question to bed," says Michael Bird at James Cook University in Cairns, Australia.

One problem with working out how humans arrived in Sahul is that the timing is hazy. The ancient archaeological record is sparse, says Bird, perhaps because colonists stuck to coastal regions that are now under water. The oldest known site is a rock shelter called Madjedbebe in Australia's Northern Territory. In the 1970s, archaeologists dated it to around 50,000 years ago. The most recent excavations have pushed that back to 65,000 years, give or take five millennia, though these claims aren't universally accepted. The oldest undisputed date is 47,000 years ago.

But the idea that humans could have been in Sahul some 70,000 years ago is looking increasingly plausible. A recently discovered settlement on the Indonesian island of Sumatra – a possible staging post on the way to Sahul – is roughly that old, and a 2016 analysis of Australian Aboriginal DNA also points in the same direction.

In which case, the journey looks slightly less daunting. Sea level was 10 metres lower 70,000 years ago than it was 50,000 years ago, which would have further reduced the distances involved. That isn't a major factor in Indonesia's Wallacea islands, with their steep coastlines. But the Sahul coast would have been significantly closer to the easternmost of the south-eastern Asian islands.

> **"How did ancient people even know Sahul was beyond the horizon?"**

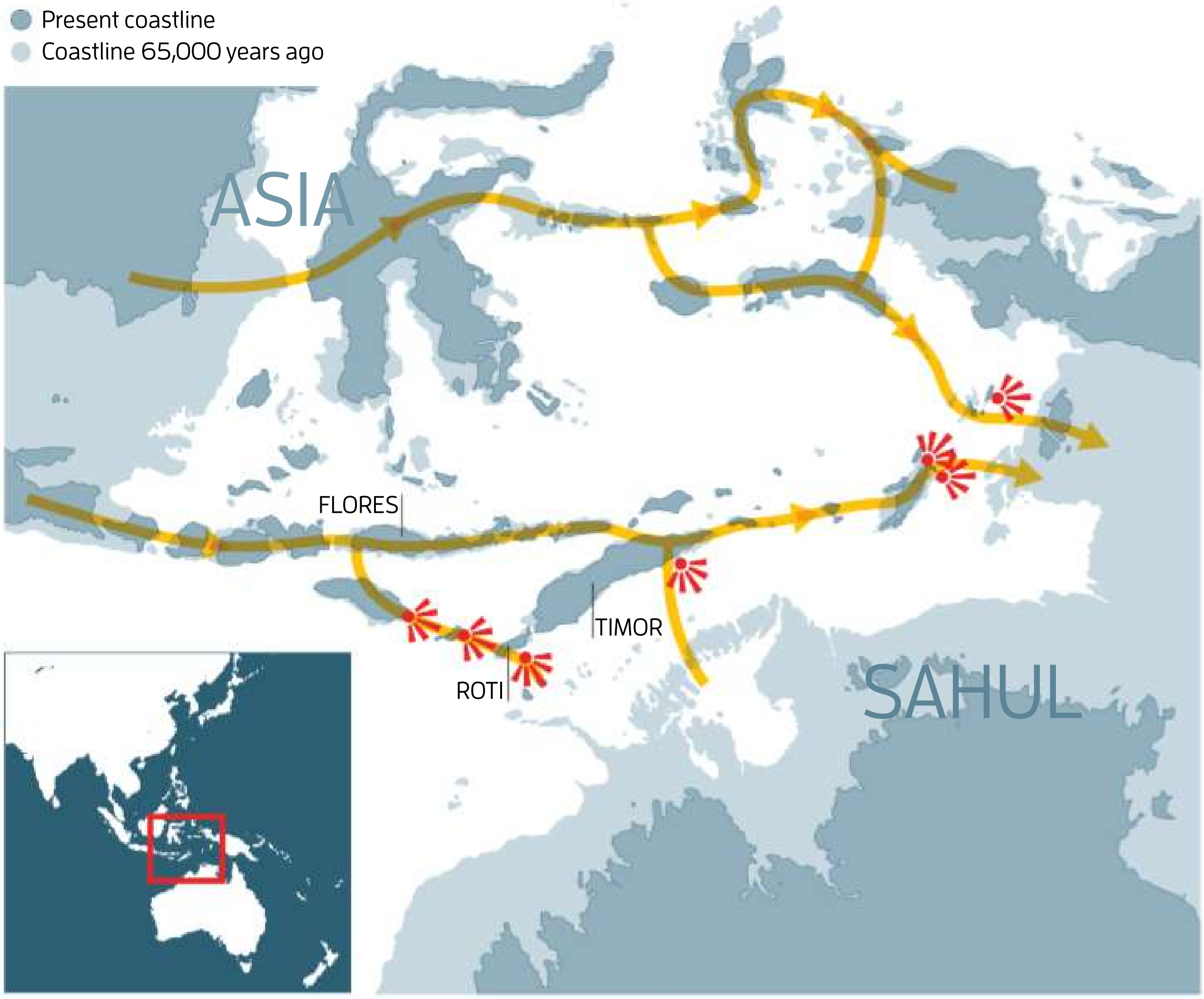
That doesn't necessarily mean the journey was deliberate, but two fresh lines of evidence seem to support the idea that it was.

The first concerns the route taken by the colonists. Archaeologists have long recognised that there were two plausible options (see map, page 40). The northern route begins on the island of Sulawesi, hops across other islands of Wallacea and makes landfall in Sahul on the western tip of New Guinea. The southern route starts on the Indonesian island of Java, which would have been part of the Asian mainland then, traverses the Lesser Sunda Islands to Timor, then either heads south to the coast of Sahul or continues east to the edge of the – now submerged – Carpentarian Plain.

Even at the lowest sea level, both routes require at least one crossing approaching 100 kilometres and several of 20 to 30 kilometres, says Bird. That puts the destination over the horizon. With no knowledge of the curvature of the planet, how did people know that Sahul was even there? It is possible that they climbed headlands or peaks to scan for distant land, ›

Over the horizon

Ancient humans could have reached the lost continent of Sahul from south-eastern Asia via several **possible routes**, most of which require at least one sea crossing in which **no land was visible** at launch



SOURCE: NATURE

> **“One way to find out if the journey was possible is to recreate it”**

or inferred its existence from clouds, smoke, migrating birds or the glow of bushfires. Even so, at some point, it appeared that they would have had to strike out into the unknown.

Both routes have their pros and cons. The northern route has fewer crossings, a shorter overall distance and plenty of the wide-stemmed bamboo that is considered ideal for raft-building. But the islands would have been heavily forested, making it hard to climb to vantage points, and prevailing north-south currents would have made it tricky to maintain the correct heading.

The southern route, by and large, has shorter crossings, although the final legs would have been longer than any on the northern route. The vegetation was savannah, which is better for reaching higher ground but worse for raft-building material. On this route, the ancient mariners would have to have used a material other than bamboo, or perhaps brought stockpiles, both of which seem unlikely.

Deciding which route was more likely depends on a detailed understanding of the ancient ocean currents and climate. Last year, Bird’s team used computer modelling to drop virtual castaways at 17 possible crossings, then allow the currents and winds as they would have been 65,000 years ago to do their stuff. This confirmed that the possibility of randomly colonising Sahul is vanishingly small, unless implausibly large numbers of adults were being washed into the sea at unreasonably high frequencies. But it also revealed that throwing in a bit of planning – such as paddling a raft and setting off during optimal weather and currents – dramatically increases the chances of success.

Planned migration

Bird’s team also reanalysed visibility along the two routes. Contrary to previous work, they discovered a number of ways of navigating from south-eastern Asia to Sahul without ever losing sight of land. All of these are on a northern route, which affords uninterrupted views of the high mountains of New Guinea; for the southern route, all of the final crossings would have had no sight of land. This doesn’t rule out the southern route, says Bird, especially when sea level was very low and there were islands south of Timor. But it does suggest that the assumption of a complete leap into the unknown no longer holds water.

The other new line of evidence supporting a planned migration comes from Corey Bradshaw of Flinders University in Adelaide, Australia, and his colleagues. They modelled the demographics of colonisation, taking account of typical hunter-gatherer fertility rates and longevity and the ecological conditions they would have encountered after landing in Sahul. The calculations revealed that the minimum founding population was 1300 people, perhaps all at once or in smaller groups over many years, which all but rules out accidental colonisation.

The peopling of Sahul was “probably planned”, Bradshaw concludes. Bird agrees. “It is not feasible that people randomly got there,” he says. “They had to think about it and they came in large numbers.” Why they came is a different question. But the chances are they were driven by dwindling resources, or simply the lure of the unknown, says Bird.

And yet the mystery isn’t quite put to bed, says Westaway, because although the new analyses are useful, only archaeology and genetics can give us the full story. “What we are missing is ancient genomes from Sahul,” he says. These would tell us not only when people arrived in Sahul with more certainty, but also whether those people were related to the people we know were present in south-eastern Asia around the same time (see "Only humans?", below).

The trouble is that the majority of Sahul, now northern Australia, is desert. "Arid conditions are not good for the preservation of Pleistocene human DNA," says Westway. "If we're going to find it, I think it will have to come from the highlands of New Guinea, but that would require new excavations."

As for the archaeology, Bird's colleagues are carrying out high-resolution surveys of areas of Sahul that are now underwater, looking for potential sites of early human occupation. Again, though, that would require new excavations, this time on the seabed. "Underwater archaeology gets very expensive," says Bird.

For the time being, the prospects for new archaeological discoveries seem remote. When it comes to understanding how such ancient humans were able to navigate to a new continent, we are in the realms of speculation, says Westaway.

What we do know is that the minimum requirement is a raft of some kind, probably made from bamboo lashed together with plant fibres. But could a fleet of such rudimentary vessels really carry hundreds of people safely from Asia to Sahul?

One way to find out is to recreate the journey, which is exactly what an experimental archaeology project called The First Mariners is designed to do. The researchers behind the project are now on the southern tip of the Indonesian island of Rote, building a raft using stone tools and locally available materials, principally a giant bamboo known as betung which can reach 20 metres or more in height. "Almost nothing challenges bamboo for weight, strength, durability, availability, resistance to seawater and its extraordinary flotation properties," says project director and maritime historian Bob Hobman.

About 250 stems will be lashed together to create a platform 18 metres long and 4 metres wide. The deck will be supported by cross timbers foraged from the forest and held together with around 17,000 metres of rope made from the bark of the sugar palm (*Arenga pinnata*). Basic steering will be provided by a rear oar, and the giant leaves of the lontar palm (*Borassus flabellifer*) will form a rudimentary sail. "It's our secret weapon," says Hobman. "It's really not a sail, but it gives wind assistance. It's unsophisticated, but it will do the job."

And that is essentially it. The plan is to set off across the Timor Sea in early February when the north-westerly monsoon wind will be "fizzing", Hobman says. The journey will take about 14 days, although they will cross the drowned coastline of Sahul after about six. The 10-strong crew will live mainly on fish and monsoon rain. A support vessel will follow in case they get into difficulty in the shark-infested waters, but exactly what will happen is in the lap of the gods. "It's totally experimental," says Hobman. "And it will be from the moment we leave, all the way across the Timor Sea." But Hobman says he is confident of success – because he has almost done it before.

In 1998, he was part of a crew that sailed a bamboo raft called Nale Tasih 2 from Timor to within spitting distance of Australia, before they were forced to abandon ship in heavy seas. That voyage took 13 days, but used more advanced technology than was available in the middle Stone Age, including modern tools to build the boat and a woven sail.

This time the ancient mariners are going full Palaeolithic. If they make it, it won't prove that Palaeolithic humans really did navigate to Sahul; that we may never know. But it will mean we can no longer say that it was "impossible". As soon as humans were fully human, we didn't know the meaning of the word. ▮

The first mariners probably voyaged across the sea on bamboo rafts

RAY WISE/GETTY IMAGES

Only humans?

South-eastern Asia 60,000 years ago was a melting pot of archaic humanity. As well as our own species, there were at least three other hominins in the area: *Homo floresiensis* (nicknamed the hobbit), the recently discovered *Homo luzonensis* in the Philippines and the mysterious Denisovans. There is no archaeological evidence that any hominin other than our species made the challenging sea journey from south-eastern Asia to the continent of Sahul (see main feature), but genetic evidence suggests it happened.

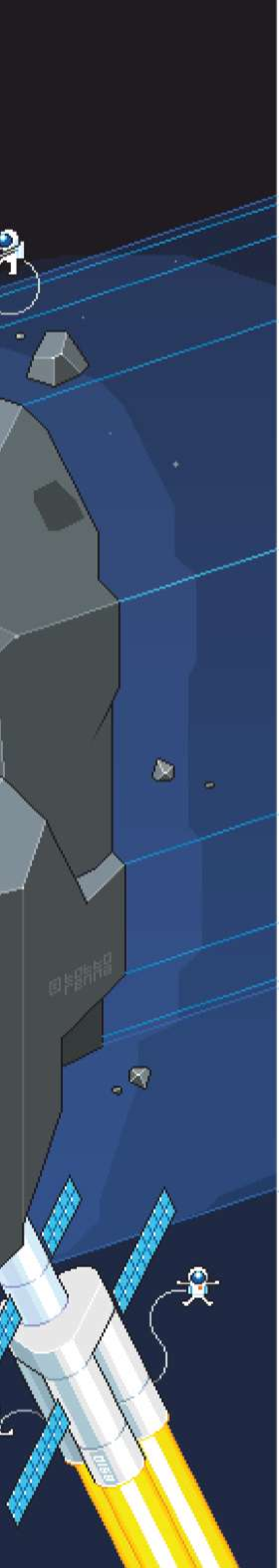
From sequencing modern human DNA, we know that there were at least two interbreeding events between our ancestors and Denisovans in the south-eastern Asia/Sahul area. One can be pinpointed to somewhere between Sumatra and Borneo, but the other is centred on New Guinea, which was part of Sahul.

This second event would mean we have another mystery to solve: how and when did Denisovans get to New Guinea, and does that indicate that they were capable of sea voyages? "We know so little about them," says Michael Westaway at the University of Queensland in Australia. "Denisovans in New Guinea would be a game changer."

Graham Lawton is a features writer at *New Scientist*

Asteroid alert!

The threat of a major collision is real. **Leah Crane** guides us through a step-by-step simulation of how we would save the planet



TOTTORENNA

IT IS just after midnight on 29 April 2027. The island of Manhattan in New York has been entirely evacuated. The lights in Times Square are off, the streets abandoned. An eerie silence hangs over the empty neighbourhoods. Overhead, a ball of rock the size of a large building is speeding towards the ground at 19 kilometres per second. In a little over a minute, if the calculations are right, it will explode in the sky over Central Park.

The city has had 60 days to prepare. Museums have been emptied of exhibits, nearby nuclear power stations shut down and fleets of buses requisitioned. Inhabitants of America's most populous urban area need to be rehoused. The matter-of-fact briefing notes for the evacuation state: "People will be leaving permanently. There will be nothing remaining."

At 00:01:38, the rock hits. A blast equivalent to 1000 Hiroshima atomic bombs turns much of New York to rubble. The economic and financial damage is incalculable. Ten million people have just lost their homes.

In a meeting hall in Washington DC, there is excited chatter as Paul Chodas declares the simulation over. His five-day exercise at the 2019 Planetary Defense Conference has played through the impact of an imaginary asteroid called 2019 PDC from detection to collision (follow the progress in italics on the following pages), to try to determine what would happen if – or when – the real thing happens.

"This is basically the worst-case scenario," says Chodas. "It all makes for a good movie plot line, of course, but they are realistic factors." Yet as the room full of astronomers, engineers and government decision-makers has just found out, happy endings aren't guaranteed.

The risk of an asteroid collision is the price we pay for living in our crowded bit of space. The sun's gravity attracts not only the moons and planets of our solar system, but also many rocky or icy loners and vagabonds that jostle for room. So far, astronomers have spotted more than 21,000 asteroids with orbits that are set to bring them close to our world. Every day, another one of these near-Earth objects is discovered.

For most of them, the chance of striking Earth is close to zero. As for the rest, the vast majority aren't worth worrying about. Tens of thousands of tonnes of material falls from space every year, most of it in the form of inconsequential particles of dust. Even an asteroid the size of a car would burn up in the atmosphere, putting on a light show but not causing any destruction on the ground. At the other end of the spectrum, there are asteroids such as the one that hit Chicxulub in what is now Mexico about 66 million years ago, wiping out the dinosaurs. That one measured somewhere between 10 and 81 kilometres across. Thankfully, such monsters are both incredibly rare and big enough to see coming (see "Crater creators", page 45).

"We've found the vast majority of the 'dinosaur-killing' class of object, which is great, but when it comes to objects just below that size, there are a lot of them out there," says Amy Mainzer at the University of Arizona's Lunar and Planetary Laboratory. We have only found about one-third of the objects we think are capable of flattening a small country, and less than half of the asteroids that could destroy a city. Objects of this size pose a real risk, being both large enough to cause serious damage but small enough to avoid detection.

When the sky falls in

"An asteroid impact is one of the few natural disasters that we know how to prevent if we detect it far enough ahead of time," says Johnson. The majority of asteroid surveys are funded by NASA. In 2005, it set a goal to detect, track and characterise 90 per cent of the near-Earth objects that are 140 metres across or larger by the end of 2020. One way to tell how we are doing is to count how often our observatories rediscover the same objects. The fewer new objects we spot, the more confident we can be that we have spotted most of the asteroids out there. So far, we have found less than half of those that astronomical estimates suggest there should be. Even though none of the ones we have found has a significant chance of hitting Earth in the next 100 years, those are worrying statistics.

"With the telescope capabilities we have now, not seeing an incoming asteroid in time to prevent an impact is a distinct possibility," says Johnson. Part of the problem is that ground-based telescopes need Goldilocks conditions in which to work. "They can only operate at night, in clear weather, when the moon is not full so the sky isn't too bright," he says. We have failed to observe large asteroids making relatively close passes by Earth several times, including as recently as mid-2019, he says. Luckily, none of those has been on a collision course with us. That said, the more pressing danger is still likely to be from something we do see coming. ›

◆

In Washington DC, Chodas begins to unveil the details of his meticulously planned exercise. It starts innocuously enough, with the observation of what appears to be a near-Earth object by the Pan-STARRS telescope project in Hawaii. The date within this fictional scenario is 26 March 2019. As per protocol, the observation is passed on to the Minor Planet Center (MPC), which is run by the International Astronomical Union. The MPC gives it the official designation 2019 PDC, and starts collating observations made by other astronomers. The Center for Near Earth Object Studies at NASA's Jet Propulsion Laboratory in California is notified. The researchers there alert Lindley Johnson at NASA's Planetary Defense Coordination Office, who sends the necessary details to NASA headquarters and the rest of the US government. For the moment, sustained tracking is the main priority. There is no reason for immediate concern.

◆

Asteroid watchers make all their data public, so whenever a potentially dangerous object is spotted, astronomers in different countries simultaneously evaluate the risk. In 2013, the United Nations recommended that the global effort be more organised, so the International Asteroid Warning Network was formed with astronomers and space agencies from Europe, Asia and North and South America. Should they all agree that an impact really could be catastrophic, the network sends a message to the United Nations Office for Outer Space Affairs, which gathers member states together to discuss what they should do about any impending threat.

Their plan will depend significantly on what we know about the asteroid and where it is going to hit. In the best-case scenario – if it is a small object likely to burn up in the atmosphere or if it will only hit the middle of an ocean – we might choose to do nothing, or simply warn people in the affected area to stay away from windows that may be shattered by an explosion in the atmosphere. In the worst-case scenario, we may not have time for anything but evacuation, says Johnson.

Ideally, we would detect the asteroid decades, or at least years, before it is projected to hit Earth. At that point, we won't know exactly where it is going to hit, but we will be able to say with some certainty that it is headed towards us. The moment we know that, it is time to start planning.

◆

For attendees of the Planetary Defense Conference, that time is now. The date is 29 April 2019, and we know that 2019 PDC is likely to cross our planet's orbit in eight years' time – around the end of April 2027. The probability of a direct impact remains low, near 1 per cent. Given the asteroid has a diameter of roughly 200 metres and could cause major damage, this is fortunate. On the Torino scale used to rank such objects from 0 up to 10 – the most dangerous – it is classified as a 2, which means it "merits special attention". As per UN General Assembly resolution 71/90, the International Asteroid Warning Network begins coordinating preparations.

◆

"If there is a high probability of impact, and when I say high probability mean just about 10 per cent, we should not wait to be developing a mitigation-capable mission," says Johnson. Because such a mission to intercept an asteroid would take about three years, he adds, "if you wait until you know for sure where it's going to hit, it's going to be too late".

RANDY OLSON/NATIONAL GEOGRAPHIC

Australia's Wolfe Creek crater was formed by an impactor 15 metres across

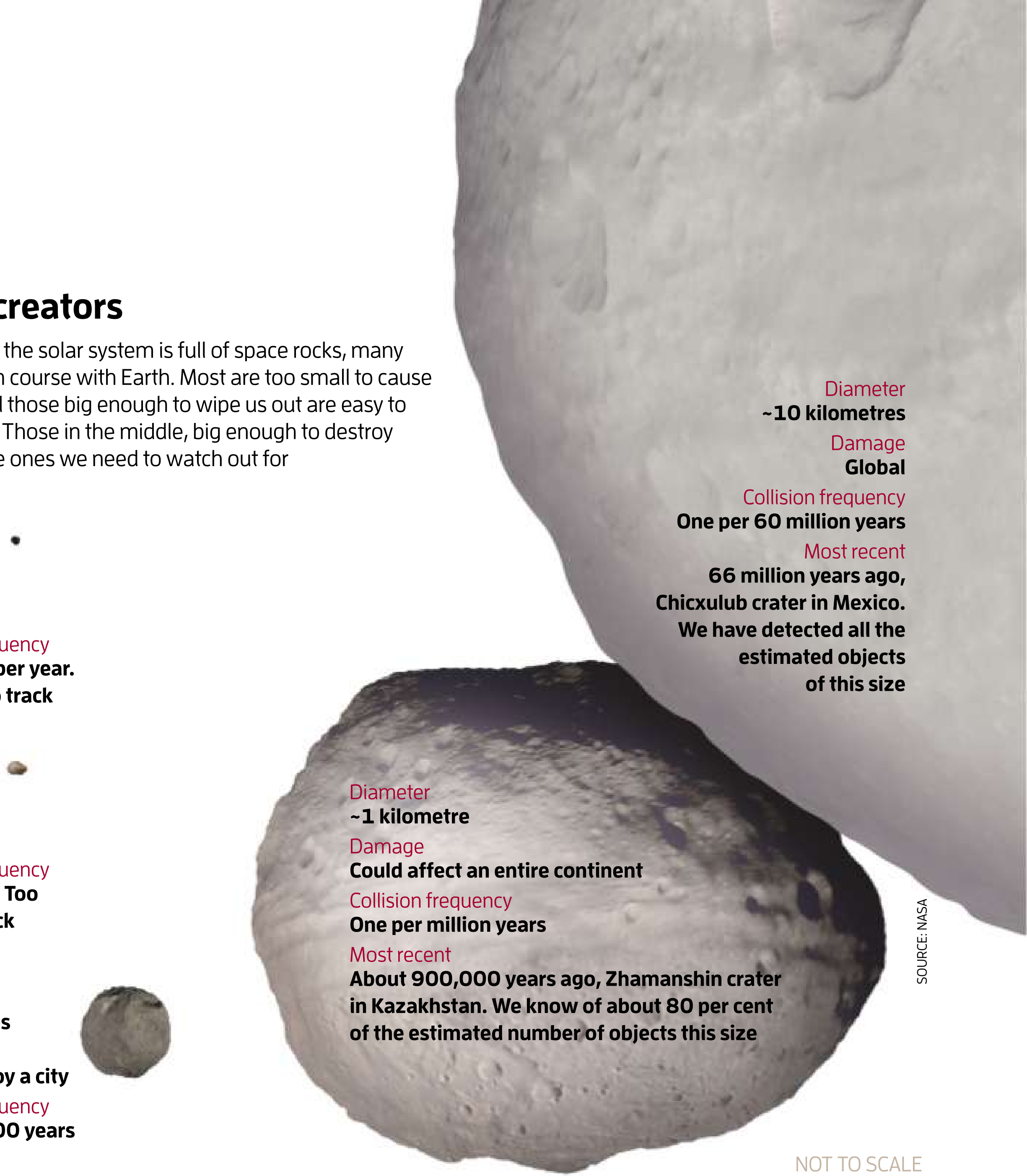
* * *

Back in Chodas's simulation, it is 29 July 2019, and the chances of 2019 PDC colliding with Earth have just reached 10 per cent. Calculations indicate that the most likely points of impact are in two belts: one running from San Francisco to New York in the US, and the other across Africa from Nouakchott in Mauritania to Lilongwe in Malawi. At its newly calculated size of 185 metres, it has the potential to render entire cities uninhabitable. The advice to space agencies is to begin mitigation work immediately. The first priority: launch a reconnaissance mission to the asteroid. We have less than two years to do so.

* * *

Crater creators

Our patch of the solar system is full of space rocks, many on a collision course with Earth. Most are too small to cause damage and those big enough to wipe us out are easy to see coming. Those in the middle, big enough to destroy a city, are the ones we need to watch out for



Diameter
<1 metre
Damage
None
Collision frequency
Thousands per year. Too many to track

Diameter
~1 metre
Damage
None
Collision frequency
30 per year. Too many to track

Diameter
~100 metres
Damage
Could destroy a city
Collision frequency
One per 2000 years
Most recent:
Tunguska event in Russia, 1908. We know of less than half of the objects this size that astronomers suspect are out there

Diameter
~1 kilometre
Damage
Could affect an entire continent
Collision frequency
One per million years
Most recent
About 900,000 years ago, Zhamanshin crater in Kazakhstan. We know of about 80 per cent of the estimated number of objects this size

Diameter
~10 kilometres
Damage
Global
Collision frequency
One per 60 million years
Most recent
66 million years ago, Chicxulub crater in Mexico. We have detected all the estimated objects of this size

NOT TO SCALE

SOURCE: NASA

Once we know an asteroid is on a collision course with Earth, there are two main options: blow it up or change its trajectory. Shattering it with a nuclear bomb, the course favoured in disaster movies such as *Armageddon* and *Deep Impact*, tends to be a non-starter for political reasons. "There is a problem with international treaties: you cannot really launch nuclear weapons into space," says Peter Vereš, an astronomer at the Minor Planet Center.

It is also an issue of practicality: when you blow up an asteroid, the shrapnel doesn't just disappear. They are probably still headed towards Earth, and they might not all be small enough to disintegrate in the atmosphere. "You're not going to eliminate it, so you're going to have, instead of a single object coming at you, essentially buckshot," says Johnson. "That could spread the devastation over a broader area of Earth." It also makes the danger less predictable.

So we are left with one good way of getting rid of an incoming asteroid: we will have to push it off course. For a long time, the most popular proposal was a gravity tractor, a large spacecraft that would fly close to an asteroid, slowly changing its trajectory via the craft's own gravitational attraction without ever actually touching it. This method would be slow, though, so most of the work in recent years has shifted to the use of kinetic impactors: spacecraft that simply slam into the approaching rock to change its course.

* * *

The Planetary Defense Conference is now in its third day. Within the world of the simulation, that is 30 December 2021, and Recon 1, a spacecraft sent to observe 2019 PDC, has vital new information. We now know, with near 100 per cent certainty, that the asteroid is on course to impact near Denver, Colorado. Deploying a nuclear missile to deflect the asteroid is deemed too controversial, and so all efforts are devoted to kinetic impactors. To give the asteroid the shove it needs, six rockets must be launched at the end of May 2023, scheduled to collide in August 2024. This will require the collaboration of multiple space agencies, each sending the heaviest rockets at their disposal on a one-way mission. The launch times of these rockets are all precisely fixed: the orbital dynamics gives us just one shot at getting this right.

* * *

Before we can do anything like that, we have to learn more about asteroids. "It's much easier to protect ourselves if we know our enemy," says Vereš. We already know that some asteroids are porous bundles of rock called rubble piles, whereas others are solid iron. There is probably a spectrum of different compositions in between. Knowing their composition matters, says Mainzer. "The physics of pushing something out of the way is dependent on its nature."

So, immediately after detecting a dangerous asteroid, the race to characterise it will begin. Earth-based telescopes will tell us its size and shape, as well as its reflectivity. We expect less-reflective asteroids to have lower densities because they are a porous mixture of rock and ice, whereas brighter asteroids are likely to be more solid. Radar data could also let us define the orbit more precisely and look for any big boulders or moons that might be orbiting the asteroid and making it even more dangerous.

There is a limit to how much we can find out about asteroids from the ground, though. That is why NASA's OSIRIS-REx and Japanese space agency JAXA's Hayabusa 2 missions to bring back samples from potentially hazardous asteroids are so important. "Studying meteorites is great, but with these missions, we can see what they look like without getting fried by flying through Earth's atmosphere at 20,000 miles per hour," says Mainzer.

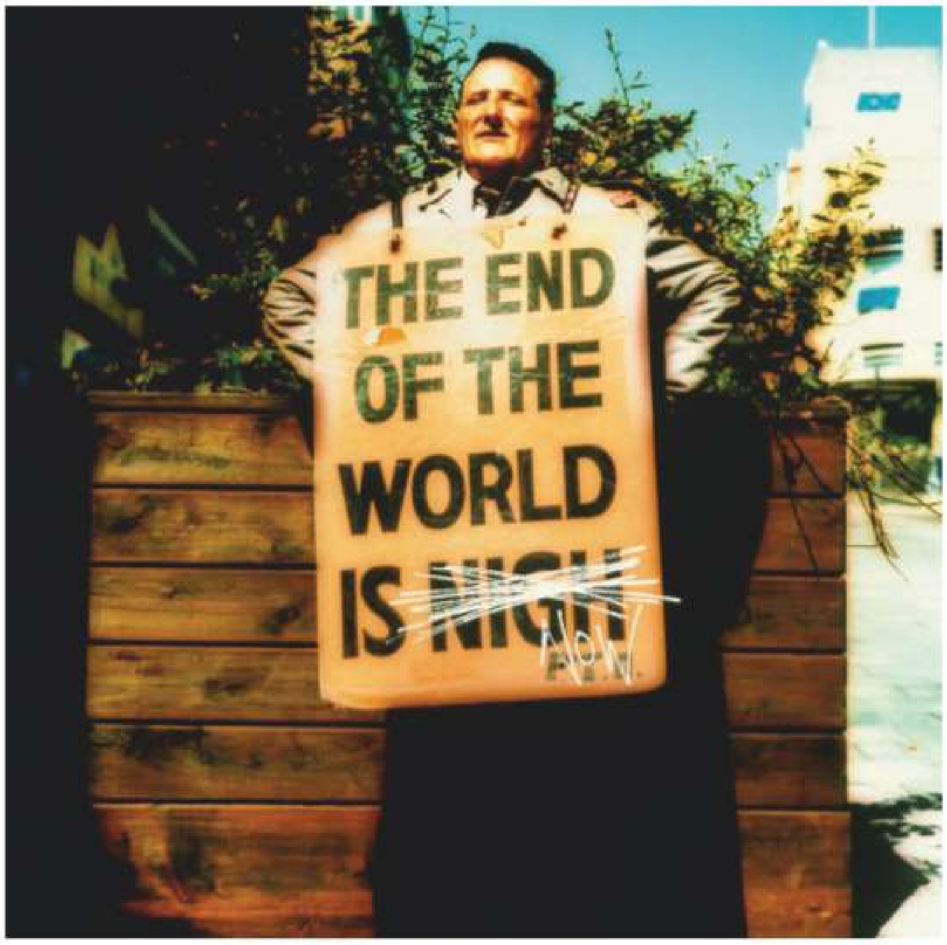
So far, both of the asteroids being visited by NASA and JAXA – Bennu and Ryugu – are more porous than we expected, with Bennu being 40 per cent pores and caves, and Ryugu as much as 50 per cent empty on the inside.

That could present a problem for a potential kinetic impactor mission. "If an asteroid is a rubble pile, it has lots of holes inside, so if you punch it, it might change shape but not change its orbit," says Vereš. "It's like hitting a sponge with a baseball bat." If these rubble-pile

›

THEY JUST MIGHT WORK

Two methods are considered the most credible ways of helping us divert asteroids on a collision course with Earth (see main story), but other, wackier, ideas are also being taken seriously. The simplest would be to paint one side of an asteroid white or silver. The painted part would then reflect more sunlight and the energy imparted by the extra light bouncing off that surface could change the asteroid's trajectory. Alternatively, we could attach engines to an asteroid and turn it into a spacecraft, or use high-powered lasers that could vaporise rock. While demolishing an entire asteroid with a laser is unlikely to be possible, the puff of dust jetting off the surface could act like a thruster, allowing us to push it off course. Such ideas could work, but are untested and would probably take decades or require technology we don't yet have, so they aren't part of any official plan.



With the right preparation, apocalypse can be averted

ALAN POWDRILL/GETTY IMAGES

asteroids are common, which seems likely, we need to study and test the effects of a kinetic impactor more carefully.

NASA is on the job with the Double Asteroid Redirect Test (DART) probe. DART is due to launch next year to the asteroid Didymos, where it will deliberately crash into the asteroid's 150-metre moonlet, nicknamed Didymoon. That is expected to change Didymoon's orbit enough for the effects to be visible from Earth. Once we know how crashing into an asteroid (or, in this case, an asteroid moon) affects its motion, we will be much better equipped to build a kinetic impactor – and guarantee it works.

* * *

Chodas has good news and bad news. The good news is that the kinetic impactor missions have hit 2019 PDC, and the bulk of the asteroid is no longer on course to hit Earth. The bad news is that a fragment about 60 metres across remains on its original trajectory. That isn't all: contact has been lost with the Recon 1 spacecraft, probably owing to collision with debris. The resulting lack of information is compounded by the asteroid now being behind the sun, making it impossible to observe from Earth. Our options are limited. It is now 3 September 2024, and as the collision time approaches, the momentum needed to disrupt the fragment's trajectory sufficiently to avoid Earth rises. But given the asteroid's small size, any disruption is likely to break it apart, causing a repeat of today's scenario. A radical proposal is raised for a deliberately robust collision, shattering the rock into such small pieces that no damage to Earth's surface will result. That means a nuclear device is needed. The legality of such a launch sparks heated debates. Meanwhile, time ticks on.

* * *

Ultimately, a disastrous asteroid strike of this sort remains very unlikely. But we should still be prepared. That means working on more mission concepts (see "They just might work", above), building more telescopes to look for asteroids and maybe moving them into orbit so that they can operate 24/7. For Chodas, that also means running more "what if" scenarios, testing the limits of our contingency planning. "In each one of these exercises, we go a little deeper into interesting details and we are forced to think about issues that we haven't thought about before," he says.

This most recent scenario, for instance, brought home to him the scale of the disaster response required. "Evacuating a large metropolitan area, of course, would be a daunting task," he says. "What was eye-opening for me was how long that would take." As for how life resumes on the day after the sky falls in, that is beyond his remit. "That's something that FEMA [the US Federal Emergency Management Agency] would address after the fact, like they do for other disasters."

But thanks to planetary defence research, the chances of such a clean-up ever being necessary are pretty slim. "If we try hard enough," says Mainzer, "it's something that we can cross off our list of worries." An asteroid probably won't kill us all. But it would be good to know for sure.

* * *

A last-ditch nuclear strike on the asteroid remnant has been cancelled for lack of time. The collision has been inevitable for weeks. Last night, the Arecibo Observatory in Puerto Rico confirmed the space rock would explode above Central Park, New York, in 10 days' time, after approaching Manhattan at an angle of 29 degrees south of due east. By a quirk of fate, that matches the orientation of many of the island's streets, giving any life forms in the city an uninterrupted view of the incoming fireball. The 9/11 attacks damaged an area of around 16 acres; 2019 PDC is expected to render 20,480 acres uninhabitable. The evacuations begin immediately. ■

Leah Crane is a reporter for *New Scientist* based in Chicago. She tweets @downhereonearth

New Scientist Jobs

newscientistjobs.com

Recruitment advertising

Tel **+1 617-283-3213**
Email **nssales@newscientist.com**

Bring your career to life

Sign up, create your own job alerts and discover the latest opportunities in life sciences at
newscientistjobs.com

@science_jobs **#sciencejobs**

Intelligence Community Postdoctoral Research Program Fellowship Program

The Intelligence Community (IC) Postdoctoral Research Fellowship Program offers scientists and engineers from a wide variety of disciplines unique opportunities to conduct research in a wide range of topics relevant to the Intelligence Community. The research is conducted by the Postdocs, while working in partnership with a Research Advisor and collaborating with an advisor from the Intelligence Community.

In partnership with the Research Advisor, the Postdoc composes and submits a technical proposal that responds to a research opportunity identified at:
https://orise.orau.gov/icpostdoc/current-opportunities.html

Award Details:

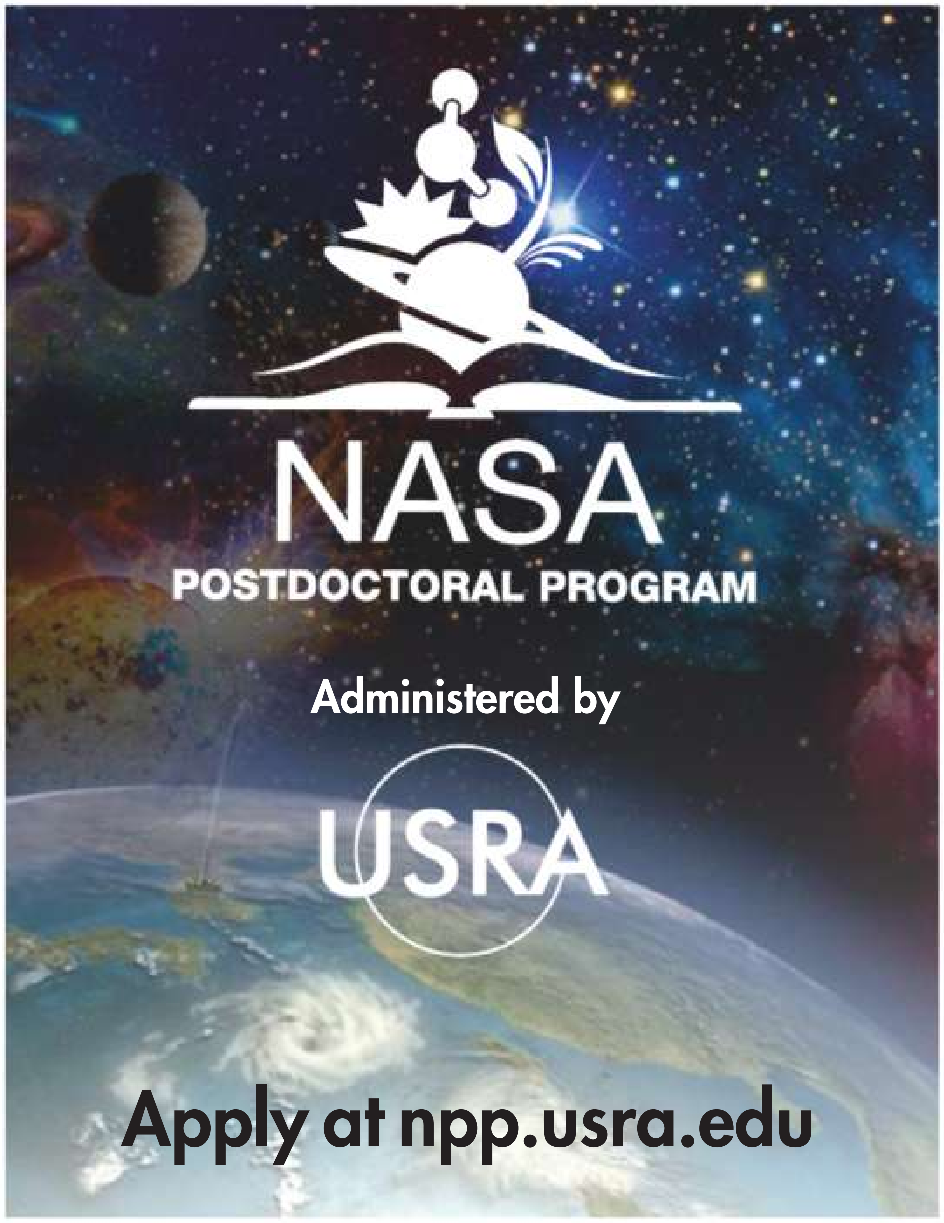
- Annual stipends range from $75,000 to $79,000, depending on research location
- Annual travel budget of up to $6,000
- Appointments for 2 years, and option to extend for a third year
- Host institutions receive an annual laboratory budget of up to $5,000
- Research Advisors receive a $10,000 stipend and an annual travel budget of up to $2,000

Postdoc Eligibility:

U. S. citizenship required
Ph.D. received within 5 years of the application deadline

To learn more and to apply, please visit
https://orise.orau.gov/icpostdoc/

Applications Accepted January 6 - February 28, 2020



UNM

COMPREHENSIVE CANCER CENTER

Postdoctoral Fellows – Translational Cancer Research

Postdoctoral positions are available immediately to investigate mechanisms of target organ metastatic specificity, notably to brain. Specifically, unique scientific opportunities are presented for deciphering the biology and therapeutic utilities of Circulating Tumor Cells (CTCs) directly isolated and characterized from cancer patients - “seeds” of fatal metastatic disease. Positions relate to highly relevant and innovative programs of translational cancer biology using cutting-edge concepts and technologies.

Postdoctoral Fellows will be responsible implementing programs in the cell, molecular and translational biology of CTC metastatic specificity interplaying with dormancy and quiescence; involving the use of human CTCs/cell lines, pre-clinical CDX models and clinical samples reflective of disease status. Ph.D. is required. Extensive state-of-the-art CTC platforms, technologies and know-how are available in a well-funded and well-run laboratory.

Candidates must possess:

- Intellectual curiosity in a highly-focused scientific environment and a profound motivation to succeed as a scientist in a highly-focused scientific environment;
- A strong laboratory experience with penetrating knowledge of cell/molecular biology techniques, proficiency with animal experimentation, bioimaging, and strong abilities to work independently with self-initiative, pro-active thinking and action;
- Highest work ethic and scientific integrity.

Salary and benefits are competitive and commensurate with research experience and background they are based upon the NIH Ruth Kirschenstein Postdoctoral Fellow Scale. Please send inquiries, including a Curriculum Vitae, and arrange for three letters of References (e-mails are OK) to be sent to:

Dario Marchetti, PhD
Professor, Division of Molecular Medicine
Department of Internal Medicine
UNM Comprehensive Cancer Center
Phone: (505) 272-7937
E-mail: dmarchetti@salud.unm.edu

The University of New Mexico Comprehensive Cancer Center is the Official Cancer Center of New Mexico and the only National Cancer Institute-designated Cancer Center in a 500-mile radius. One of the premier cancer centers nationwide, the UNM CCC has more than 125 board-certified oncology physicians, forming New Mexico’s largest cancer care team.

St. Elizabeth
HEALTHCARE

Medical Director of Clinical Research

The Clinical Research Medical Director will be responsible for leading and expanding the Clinical Research Institute at St. Elizabeth Healthcare.

Requirements:

- MD/DO, PharmD, or PhD
- Minimum of 7 to 10 years of research experience

Preferred Qualifications:

- MPH Experience
- Experience authoring research papers for peer review journals
- Public speaking experience at conferences / symposia
- Experience with specialty medications or devices

Responsibilities include:

- Implement program vision and strategy
- Establish short and long-range goals for growth
- Lead intra/inter-departmental teams
- Driving physician activation / participation
- Educating physicians on the impact / value of clinical research
- Mentor and coach primary investigators to address specific clinical needs and implement best practices to conduct clinical research
- Chair the Clinical Research Institute Governance Board
- Ensure compliance / alignment with protocols, guidelines, applicable regulations, and standard operating procedures
- Monitors designated operating and capital budgets
- Participate in development opportunities to increase the visibility of the Clinical Research Institute and generate funding support

About St. Elizabeth Healthcare:

We are a four-hospital, 1,000 bed community health system in a market of 400,000 people. St. Elizabeth is home to a Family Medicine Residency Program and, in partnership with the University of Kentucky and Northern Kentucky University, a medical school. Through our affiliations with the Mayo Clinic Care Network and the University of Kentucky Markey Cancer Center, collaboration with both organizations exists for clinical, educational and research purposes.

Please contact Michele Kenner at **Michele.Kenner@stelizabeth.com** to learn more about this opportunity to direct an emerging world class clinical research program in the Greater Cincinnati area.

INNOVATION CUP 2020

10th Anniversary

Great minds come together at Merck KGaA, Darmstadt, Germany

What's in it for me?

If you are a post graduate student with an interest in the pharmaceutical and chemical industry, the Innovation Cup is your chance to gain in-depth knowledge about research and development, to network with top students from around the world and to build a business case together with experienced professionals.

Who can apply:

Advanced students and post docs in the fields of life science, material science, data science and business administration from all over the world can apply:

- Sciences: Post graduate students on their way towards a PhD in biology, medicine, biotech, bioinformatics, data sciences, biochemistry, chemistry, pharmacy, physics or engineering.
- Business: Advanced MBA students and recent MBA graduates with an interest in the pharmaceutical and chemical business and a science background.

The Innovation Cup will comprise the following team topics: oncology, immuno-oncology, autoimmunity, drug discovery technologies, digitalization, electroceuticals, lithography.

How it works:

During a one-week Summer Camp, 50 selected students will attend in-depth presentations about the pharmaceutical and chemical industry given by researchers and managers at Merck KGaA, Darmstadt, Germany. The participants will be divided into teams, work together to develop a business plan and present it to a grand jury, who will award the Innovation Cup for the best plan along with a cash prize of EUR 20,000 plus EUR 5,000 for the runner-up.

A conference with alumni of previous Innovation Cup editions will be held on the first day of the Summer Camp.

Further information about the program and how to apply online from November 1, 2019, until January 31, 2020:
http://innovationcup.emdgroup.com

Location:

Near Frankfurt, Germany, June 20–26, 2020.
Travel, accommodation and food expenses will be paid by Merck KGaA, Darmstadt, Germany.

Merck KGaA
Darmstadt, Germany

SOUVENIR ISSUE
MOON LANDING
50TH ANNIVERSARY
1969-2019

NewScientist
THE COLLECTION

THE QUEST FOR SPACE

Don't miss a special souvenir issue from *New Scientist* celebrating the 50th anniversary of the moon landings. Explore the past, present and future of space exploration with over 100 pages of in-depth articles on the wonders of the solar system, plus 20 pages of newly resurfaced historical content from *New Scientist*'s archive detailing the original space race as it happened

Available from all good magazine retailers, digitally in the *New Scientist* app or direct from

newscientist.com/thecollection

The back pages

Puzzles
A black hole cryptic crossword and a land problem p52

Feedback
Spoon-bending and military dolphins: the week in weird p53

Twisteddoodles for *New Scientist*
A cartoonist's take on the world p53

***Almost* the last word**
Red sky at night and shampoo vs shower gel: readers reply p54

The Q&A
Brendan Walker on designing thrilling experiences p56

Science of cooking Week 4

A celebration of flavour

For Chinese New Year, why not make tofu and turn it into a multisensory experience, says **Sam Wong**

Sam Wong is social media editor at *New Scientist*. Follow him @samwong1

What you need

Soya beans
Cheesecloth (muslin)
Nigari (magnesium chloride)
Container with holes for drainage

For next week

Salmon
Salt
Sugar
Dill

Next in the series

1 Caramelising onions
2 Making cheese
3 Science of crispiness
4 Tofu and Sichuan pepper
5 Gravlax and curing
The science behind an age-old technique
6 Tempering chocolate
7 Umami and flavour
8 Perfect pancakes
9 Kimchi and fermentation
10 Sourdough bread

JAMES WINSPEAR

Science of cooking online
All projects are posted at
newscientist.com/cooking **Email:** **cooking@newscientist.com**

THE Chinese New Year begins on 25 January, and to mark it – and Veganuary – I am going to make tofu. Because the subtle charms of tofu can struggle to win affection, I am including a tofu-based recipe that is not only packed with flavour, but also provides multisensory stimulation.

One way to do this is with chilli peppers, which contain a chemical called capsaicin. This activates TRPV1 receptors in your mouth, which are sensitive to heat. Stimulating them sends signals to the brain that we perceive as heat. Some people find these sensations pleasurable, perhaps because they may stimulate the body to release hormones called endorphins, although this is speculative,

In Sichuan province, China, chillies are eaten in prodigious quantities, often alongside another ingredient with strange properties. Sichuan peppercorns come from a tree in the citrus family. Their effect is quite unique: they create a numb, tingling sensation in the mouth similar to pins and needles.

The molecule responsible is called sanshool. A 2013 study found that it generated sensations that we perceive as a 50-hertz vibration, a frequency that activates our Meissner receptors, which are responsible for detecting light touch.

Making tofu is a lot like making cheese, and the first step is to create soya milk. Avoid off-the-shelf soya milk because it doesn't coagulate well. Soak 250 grams of soya beans overnight, then drain and blend them with 2 litres of water. Heat the resultant milk until it begins to boil, then strain it through muslin and squeeze out as much liquid as possible.

Curdle the soya milk by adding nigari, which you can find online. It is a salt produced from seawater, and mostly contains magnesium chloride. It acts as a coagulant because the positively charged magnesium ions link up the milk's negatively charged proteins.

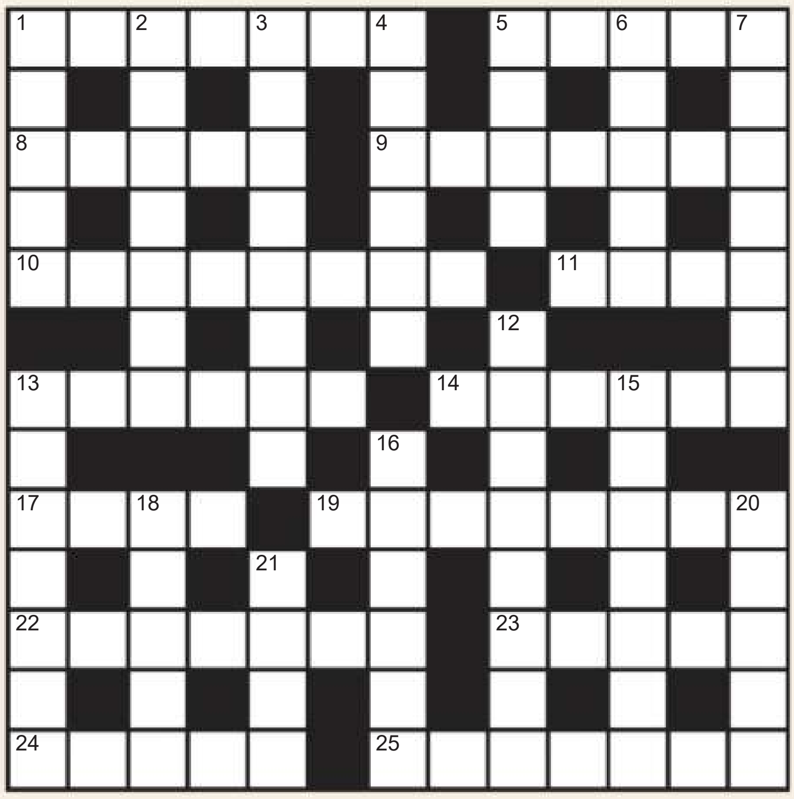
For this, mix 15 grams of nigari with 100 millilitres of water. Bring the milk to a boil again, then remove from the heat and stir in half the nigari solution. After 2 minutes, sprinkle the rest on the milk and stir gently. After 10 minutes, you will have solid curds.

Transfer these to a muslin-lined container. This needs to allow liquid to drain out: a plastic container with holes in the base is fine. Fold the muslin over the curds and put something weighty on top to press the liquid out. Keep it there for 20 minutes, or longer for firmer tofu. Cold water will help firm it up more.

My favourite way to eat tofu, from Lizzie Mabbott's book *Chinatown Kitchen*, is to dust cubes of it in cornflour and deep-fry them. Grind and toast a teaspoon of Sichuan peppercorns, then stir-fry for 3 minutes with chopped chillies. Add chopped garlic, spring onion and the tofu cubes, then fry for a few minutes more. Serve with rice or noodles. Happy New Year! ▮

Cryptic crossword #23 – The Black Hole *set by Sparticle*

Editor's note: Hidden in some of the dark squares are supermassive black holes. These exert an enormous gravitational pull on all white squares they share a side with, filling them with identical letters. The resulting clusters, read across the grid, spell out a secret phrase.



ACROSS

1 Ellie sounds drunk, held upside down like the butt of a pistol (7)

5 Returned "Exclamations of Pain" poster possibly fell on its own? (5)

8 Dreadful nuisance kicks the can, being fruitfully employed (2,3)

9 Cake batter now covered in cheese (7)

10 Make noise to keep quiet – like this? (8)

11 Predator hiding out in Mallorca (4)

13 R. L. Stine's lost novel about people who fix roofs (6)

14 Quick! Six is five plus one (6)

17 Appearance? Call it average (4)

19 Ice lolly melts with force for young hair-grower (8)

22 Most efficient vehicle: an estate? Only partly (7)

23 Three French swimming trunks (5)

24 See some average Titians (3,2)

25 Least significant entities lose the first tussle (7)

DOWN

1 Stink raised making argyle sweaters, say (5)

2 Strange sort of luaus the United Nations leads (7)

3 Windswept coastline the French heroes settled (3,5)

4 Rebut conspiracy theories from within homemade bunker (6)

5 Intensive studier heard to deal with mosquito (4)

6 Possessor of endless renown is troubled (5)

7 Introduce umpire to line patrol (7)

12 Secret language where wonder is under way (3,5)

13 Convict supports publication delay (4,3)

15 Damn the old-fashioned way air conditioning disrupts cures (7)

16 Warbler to mount a tremendous opening (6)

18 Order an English court to pass a bill into law (5)

20 No extreme misogynists survive... (5)

21 ... even in bed with a salamander (4)

The quiz will be back next week, as well as the next quick crossword and the solution to this crossword.

Quick Crossword #49 *Answers*

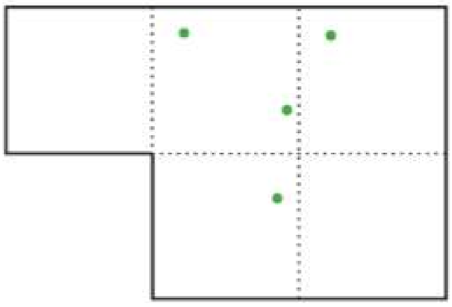
ACROSS 9 Electrophoresis, **10** Pulsars, **12** MOT test, **13** Scoliosis, **14** Nitro, **15** Arc Weld, **18** Spassky, **21** Ernst, **23** Set theory, **25** Aconite, **26** Felsite, **29** Endocrinologist

DOWN 1 Beep, **2** Seal, **3** Steatite, **4** Noesis, **5** Chemists, **6** Proton, **7** Asbestos, **8** Isotropy, **11** Ulcer, **15** Averages, **16** Concorde, **17** Dyslexia, **19** Aphelion, **20** Karst, **22** Twitch, **24** Teflon, **27** Iris, **28** Ecto

Puzzle *set by Rob Eastaway*

#43 Dividing Grandma's field

Two brothers have inherited a plot of land from their grandmother. The map below shows that the land is made up of five identical squares, and the green dots indicate the location of four old oak trees.



There are two stipulations in Grandma's will: First, the land must be divided so that the brothers get exactly half of the area each, and, second, each brother should have two of the trees on their land. The brothers would love to divide the land with a single straight fence from one edge to another. Can you find a line for the fence that fulfils everyone's wishes – and without you needing to do any measurement?

Answer next week

#42 Card conundrum

Solution

$$\frac{X}{6} = 1 - \frac{(1-X)}{8}$$

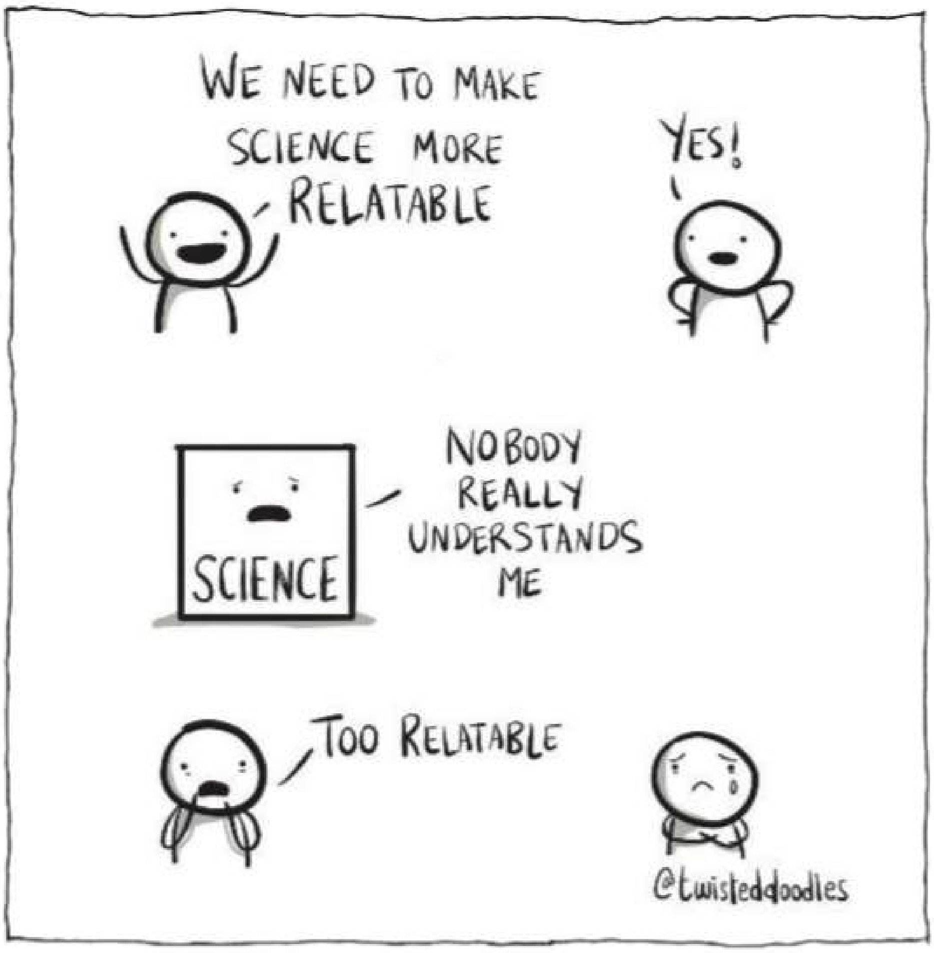
Bob's solution to this equation was X = 21.

The formula was written on a card and when Amy picked up the card she must have looked at it upside down (see below). The upside-down equation has two solutions: X = 3 and X = -3.

$$\frac{8}{(X-1)} - 1 = \frac{9}{X}$$

Our crosswords are now solvable online
Available at newscientist.com/crosswords

Twisteddoodles *for New Scientist*


WE NEED TO MAKE SCIENCE MORE RELATABLE
YES!
SCIENCE
NOBODY REALLY UNDERSTANDS ME
TOO RELATABLE
@twisteddoodles

Reverend spooner

Just as the bowl of a telepathically bent spoon arcs back ceaselessly towards its own handle, Feedback finds itself magnetically drawn to international man of cutlery Uri Geller. He has graced our pages on numerous occasions since he first rose to prominence, most recently (20 April 2019) when he claimed to be able to influence the UK's Brexit negotiations conducted by Theresa May's government.

Those particular interventions proved about as useful as a gelatin spork, but that hasn't stopped him seeking out the limelight once again. After Downing Street adviser Dominic Cummings posted a job advert looking for "assorted weirdos" earlier this year, Geller has put himself forward as the ideal candidate. In an interview with Reuters, he said that he is probably the only prospective applicant with genuine telekinetic powers. Good guess, Uri – but your numbers are off by one.

Seacret agents

Iran's alleged move towards nuclear weapon capabilities is much debated. But amid the geopolitical brinkmanship of the past few weeks, Feedback is grateful to Military.com for identifying the country's real super-weapon.

Per the publication, at around the turn of the millennium, Iran acquired a number of military dolphins from Russia, some of which – assuming low attrition rates for flipper-to-flipper combat – could still be alive. Menacing though the fleet of "communist killer dolphins" envisaged in the article may be, there is no doubt they represent a cuddlier alternative to a third world war. The most sickening aspect of war, it is often said, is that it has no porpoise.

Presidential dropout

If there is one thing we learned from politics in the 2010s, Feedback would like someone to tell us what it was. Well, maybe that's too harsh. We could, at a pinch, concede that the number of unexpected political results has taught us a valuable lesson about the unpredictability of elections, and that a much-ridiculed political candidate with a habit for odd tweets can still, somehow, be elected president.

It is with an abundance of relief, therefore, that Feedback notes that spiritual adviser Marianne Williamson has abandoned the race for the US Democratic Party's 2020 presidential nomination. Williamson, we should remind our less ardently political readers, was the candidate so widely disparaged in the mainstream press as – in her words – a "crystal woo-woo lady" that she felt obliged to state: "I've never had a crystal, I've never written about crystals. I've never talked about crystals. I've never had a crystal on stage with me."

This may well be true. But she is also the candidate who tweeted: "Let's see angels surrounding the nuclear reactors, pouring cold water over them, keeping radiation from escaping into the atmosphere" of the Fukushima nuclear disaster, and that "A new moon eclipse in Pisces tonight means huge cosmic forces make enlightened dreams come true. Just saying':)".

Let's just say that if she did have a crystal on stage with her, we would have happily voted for it over her. Just saying':)

Some watcher of the skies

They say that social media can affect a person's self-esteem, presenting them with a highlight reel of everybody else's life while skating over the difficulties. That's a gross overgeneralisation: regular media can do that, too. Take the story covered in *The Times* last week of 17-year-old Wolf Cukier. On his third day at an internship with NASA, he discovered a previously unknown exoplanet, now named TOI-1338b.

That feels like a personal attack, doesn't it? His third day. Feedback has been diligently coming into work every day for decades, and the only planet we have successfully identified is the one we are sitting on.

Our inner cynic eagerly sniffs out conspiracy. Perhaps the engineers at NASA deliberately avoid some low-hanging planetary fruit in order to reward their interns, just as truffle farmers supposedly seed their fields to keep the pigs hungry.

Alternatively, of course, NASA could just be particularly good at identifying the best and brightest young minds in the solar system. Feedback, on the other hand, is still wondering where that is.

Twitter snowstorm

In these deeply polarised times, it can sometimes feel as though certain politicians are living on a different planet. So the Twittersphere wasn't entirely surprised to find that the Trump administration had tweeted a photo celebrating the "first snow of the year!" on a day when highs in Washington DC exceeded 20°C.

What was going on? Elaborate photoshopping in the service of climate change denial? An unexplained microclimate surrounding 1600 Pennsylvania Avenue? Or yet another attempt to troll the liberal snowflakes who supposedly populate the internet?

A detailed examination by *Newsweek* revealed that the White House had simply used a photo taken a week earlier on 7 January, the actual date of the first snowfall of 2020.

An easy enough mistake to make, though perhaps the administration should consider buying whoever runs their social media feed a window. ▮

Got a story for Feedback?

Send it to New Scientist, 25 Bedford Street, London WC2E 9ES or you can email us at feedback@newscientist.com

Poetic prediction

"Red sky at night, shepherds' delight; red sky in the morning, shepherds' warning." Putting aside the occupation of the observer, is there any truth in this adage? If so, why is it true?

Richard Swifte
Darmstadt, Germany
While many pieces of weather folklore are rubbish – abundant autumn berries meaning the coming winter will be harsh, for instance – some, such as "red sky at night", contain a kernel of truth.

Over most of Europe, the prevailing winds are westerlies, so weather is most likely to arrive from the west. High pressure, which is usually associated with fair weather, tends to trap dust and other small particles in the atmosphere. These increase the scattering of blue light, leaving more red light to reach our eyes, so we see a reddened sky.

A red sky at sunset indicates high pressure to the west, so a good chance of fair weather moving in. Conversely, a morning red sky indicates that the high pressure lies to the east, so it is probably heading away, increasing the chance that a low-pressure system is arriving from the west with what is probably poorer weather.

Interestingly, a version of the "red sky at night" saying is quoted by Jesus in some versions of the Bible, in Matthew 16:2-3.

Alan Lapworth
Bedford, UK
This is said to be around 70 per cent accurate in mid-latitudes, although a persistence forecast – in other words, that tomorrow's weather will be the same as today's – is 65 per cent accurate.

In mid-latitudes, due to Earth's rotation, our weather tends to come from the west. In the UK, this often consists of depressions, with wet, windy weather lasting about 24 hours, interspersed with ridges of high pressure and fair weather.

When a high-pressure ridge approaches at sunset, the sun's rays travel through long paths of clear air, scattering blue light and leaving the red to light up any clouds above the horizon. If, however, the ridge has passed by dawn, then the clear air is to the east and a rising sun gives a red glow to any clouds. In this case, the next depression is probably approaching from the west and the weather will deteriorate during the day.

Natalie Roberts
Watford, Hertfordshire, UK
When the sun sets, any clouds it illuminates will either be emerging from the west or be partially overhead and to the west. You may have had a wet afternoon and it may rain overnight while you sleep, but if there is a red sunset, then any low-pressure rain clouds should have passed by morning and the weather should be fair. But if there are clouds reddened by the dawn, they will probably be approaching or directly overhead. Bad luck: if the clouds are rain-bearing, you will get wet that morning.

Georgina Skipper
Weymouth, Dorset, UK
In the 1980s, a survey of popular weather beliefs found this maxim was one of only two that stood up to scrutiny, the other being "swallows fly high, there'll be a blue sky". The reason for this is that swallows catch flying insects on the wing, and such insects are almost entirely dependent on warm updraughts to rise high.

Many folk sayings about weather are local and may not apply generally, despite being accurate for a smaller area. One that has been adapted for many places is: "If you can't see (insert name of place a few miles to the west), it is raining. If you can see it, it is about to rain."

OLENA HROMOVA/ALAMY STOCK PHOTO

How is a smartwatch able to track different types of sleep?

This week's new questions

Night watch The health-tracking watch I got for Christmas claims to know when I am awake or in light, REM or deep sleep. How does it do this? ***Jenny McCabe****, Folkestone, Kent, UK*

Blowing hot and cold In summer, I feel comfortably warm when the thermometer in my living room shows 20°C. Yet in winter, I feel cold at the same temperature. What causes this?
Perry Bebbington*, Kimberley, Yorkshire, UK*

Come clean

Is there a difference between shampoo and shower gel and, if so, what is it?

Cosmetic, Toiletry and Perfumery Association
London, UK
It is true that most shampoos could act as adequate shower gels, but most shower gels won't work effectively as shampoos. Both products are based on surfactants, which lather when added to water and remove oils and dirt from skin and hair. But shampoos also contain specific conditioning molecules. These are positively charged chemicals that are attracted to the hair shaft. They cling to the hair, making it smoother and easier to brush.

Lewis O'Shaughnessy
London, UK
There are some slight differences. Most importantly, shampoo contains lower levels of surfactants than shower gel does. This means it removes less of your natural oils than shower gel, allowing hair to stay healthier and less dry. The upshot of this is that you can use shampoo to wash your body – you might just need to scrub more to remove dirt – but you should avoid using shower gel on your hair.

Peter Urben
Kenilworth, Warwickshire, UK
Looking through the immense range of shampoo and shower gel in supermarkets, both products appear to have the same principal ingredients: surfactants and water. I could find no universal distinction, and some products sensibly claim to act as both. ▮

Want to send us a question or answer?
Email us at lastword@newscientist.com
Questions should be about everyday science phenomena
Full terms and conditions at newscientist.com/lw-terms

LAST FEW WEEKS
CLOSES 8 FEB 2020

MAKING
SCIENCE
HAPPEN

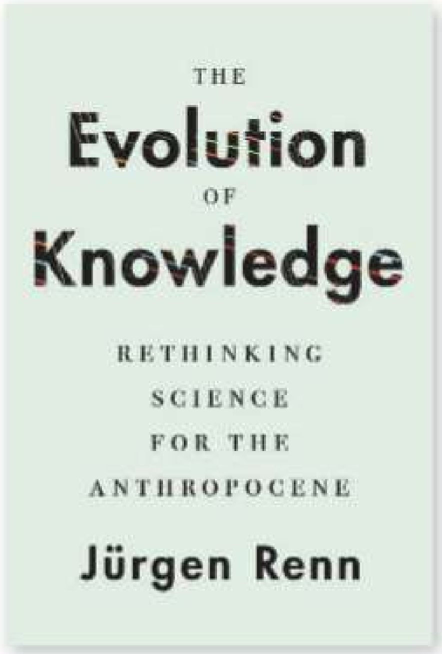
WHAT HAPPENS
BEHIND THE SCENES?

FREE EXHIBITION

1 MAR – 8 FEB 2020
KINGS CROSS ⊖

CRICK.AC.UK/CRAFTANDGRAFT

A fundamentally new approach to the history of science and technology



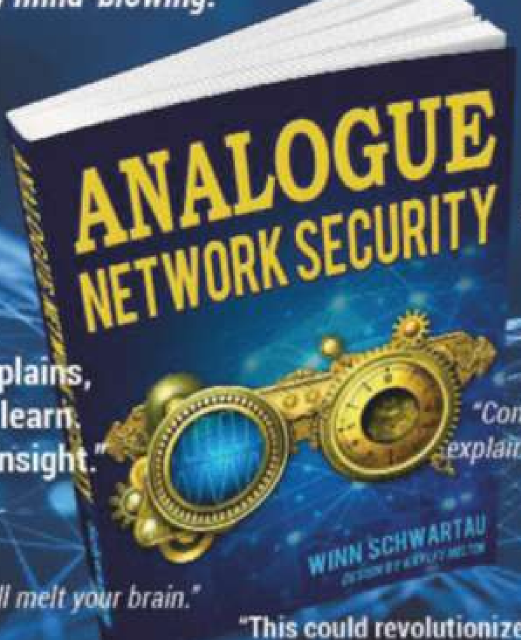
"Navigating our collective futures will require us to understand the changing nature of knowledge. This marvelous book is an extraordinarily useful guide in that task."
—Jan Zalasiewicz, coauthor of *The Goldilocks Planet*

PRINCETON UNIVERSITY PRESS

WHAT IF
we could measure and quantify security?
What if we could stop phishing, spam, DDoS, and more?

"I couldn't put it down."

"Absolutely mind-blowing."



"Will force you to re-evaluate your beliefs."

"Winn Schwartau once again challenges the status quo."

"Winn explains, and you learn. Amazing insight."

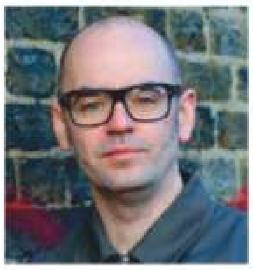
"Concepts eloquently explained and illustrated."

"This book will melt your brain."

"This could revolutionize the cyber world."

"Finally. Something new in the world of cybersecurity. Get it."

Get your free 42-page sample today!
www.AnalogueNetworkSecurity.com



Thrill engineer **Brendan Walker** designs fairground rides and spine-tingling virtual reality experiences – but says seeking kicks isn't just for adrenaline junkies

As a child, what did you want to do when you grew up?

A coal miner, a Red Devil with the British Army skydiving team, an artist and then a surgeon. In a way, they're all about exploring the unknown.

Explain your work in one easy paragraph.

I use strategies from the arts, design, engineering and psychology to create emotional experiences, for example for clients such as Nissan and Disneyland. To do that, I sometimes think like a scientist, as if I were conducting a controlled psychology experiment, and other times laterally as an artist.

How did you end up working in this field?

As a kid, I spent a lot of time trying to make people laugh and feel happy. It thrilled me when I succeeded, and it still does. I originally trained as an aeronautical engineer, decided to leave my job to do a foundation course in design and start following my dream. I supported myself flipping burgers and pulling pints – but I made it.

What's the secret to thrilling people?

There's often a fixation on adrenaline junkies and extreme thrill-seeking, but pleasure is equally as important as arousal in creating a feeling of thrill. Thrill is subjective, and most people can experience the same amount of thrill as an adrenaline junkie without going to extremes.

What achievement are you most proud of?

My formula for thrill, published in *The Taxonomy of Thrill* in 2004, which says you'll maximise it if you can create a huge, rapid rise in pleasure and arousal. This remains my golden rule in thrill engineering.

What scientific development do you hope to see in your lifetime?

Personal electric flying machines.

If you could send a message back to yourself as a kid, what would you say?

"You might feel like you're giving up art for science, but you do find a way to combine them later in life." Ugh – I'd probably throw this message away, thinking my dad had written it.

Is there a discovery you wish you'd made yourself?

Luigi Galvani discovered electricity could be used to reanimate the legs of a recently deceased frog. It was the birth of neurology (and a great party trick) and also inspired Mary Shelley to write *Frankenstein*.

If you could have a conversation with any scientist, living or dead, who would it be?

I'd have a (responsible) drinking competition with Leonardo da Vinci and Leon Theremin. They both applied creative ingenuity to science and art alike. I'd have to introduce them to Google Translate first, which might blow their minds.

What's the most thrilling thing you've worked on in your career?

I've worked on roller coasters and ejector seats for Typhoon jets, but my first virtual-reality swing gave me goosebumps. The screams as people felt like they were swinging much higher than they were made me realise I could create thrilling experiences at a fraction of the cost of a new ride or jet plane.

Do you have an unexpected hobby, and if so, please will you tell us about it?

I'm training for my third dan black belt in Shotokan karate, and have handled whippets at dog shows.

What's the best thing you've read or seen in the past 12 months?

I read Richard Harris's 1940 patent for a ride called the Twister. He shows the different spirographic movements riders will experience depending on gear ratios. It's exciting to see how he makes connections between psychology and physics.

How useful will your skills be after the apocalypse?

The apocalypse might be a little stressful, so I'd open the world's first post-apocalyptic theme park.

> "The apocalypse might be a little stressful, so after it I'll open a theme park"

OK, one last thing: tell us something that will blow our minds...

I have a defective *D4DR* gene that means I can't process dopamine as effectively as other people, and need to go to greater extremes to sense pleasure or be thrilled. I'm quite hard to buy for at Christmas. ▮

Brendan Walker is director of the Thrill Laboratory and professor of creative industries at Middlesex University London

JO LONGHURST

SUBSCRIPTION OFFER

NewScientist

Subscribe today
from only $1.91 a week*

As a *New Scientist* subscriber you also benefit exclusively from:

- **Free weekly print delivery to your door**
- **The *New Scientist* app, giving you instant access anytime, anywhere, including**
  - Current and back issues of *New Scientist*
  - All issues of ***New Scientist: The Collection*** - worth $9.99 each!
- **Full access to newscientist.com with**
  - Over 30 years of archive content
  - 100+ science talk videos
  - Early access to magazine features online

For easy online sign-up, visit newscientist.com/13565
Or call 1 888 822 3242, quoting reference 13565

* A digital subscription package to New Scientist costs $1.93 a week, made payable by quarterly continuous payment methods